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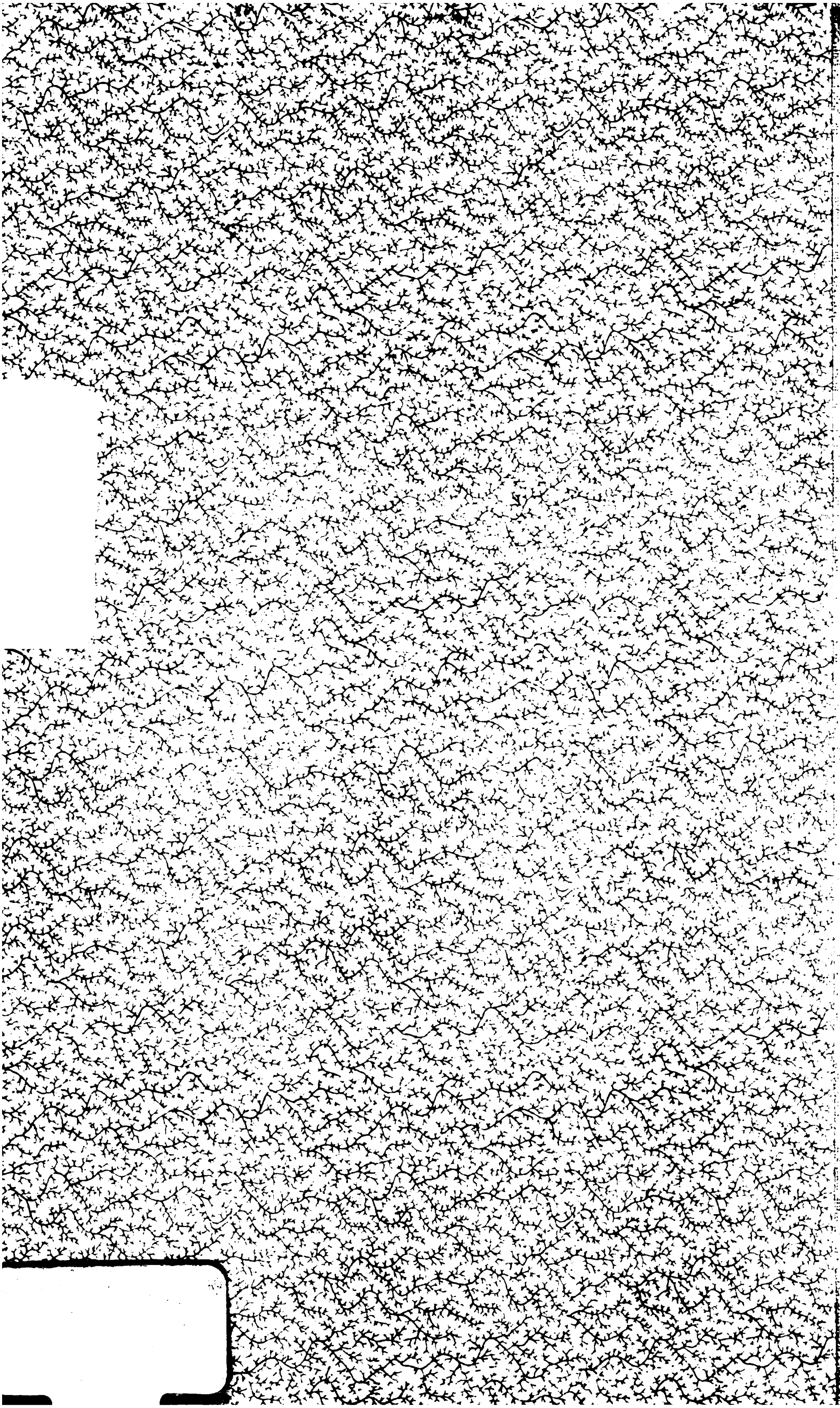

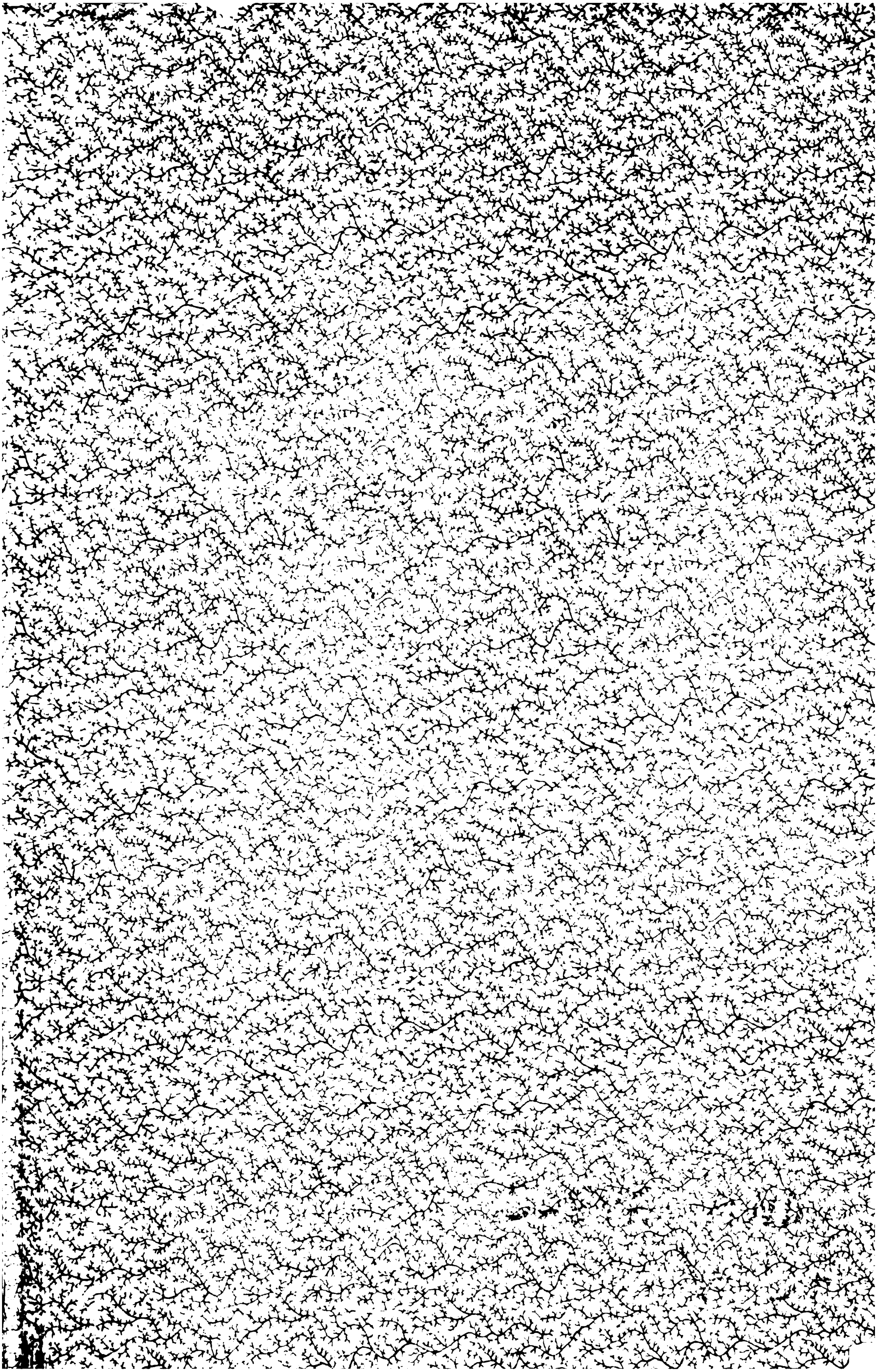

Transactions, The Civil Engineers' Club of Cleveland

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No. 1.

The Cleveland Garbage Disposal Plant

By W. J. SPRINGBORN,
President Board of Public Service.

Read at the meeting of the Club February 11, 1908.

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The Cleveland Garbage Disposal Plant

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In order to comply with the request that I reduce to writing my talk on the subject of garbage reduction, which was given at the last meeting of The Civil Engineers' Club, I believe it is advisable, on account of the readers of this paper not having before them the stereopticon views used, to confine this article to a general description of the process employed and the apparatus used in reducing the garbage.

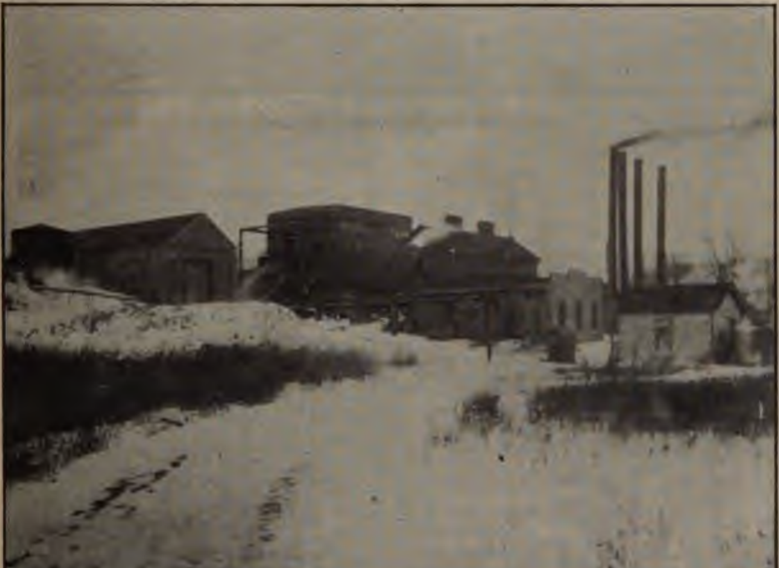


Fig. 1. **Cleveland Garbage Disposal Plant**

The loading station and the stable are located on Canal Road, adjacent to Central Viaduct, which is about three-fourths of a mile from the center of the city. Here the garbage is delivered in wagons and loaded upon cars ready for shipment to the plant, which is located at Willow, Ohio, a distance of about nine miles from the loading station.

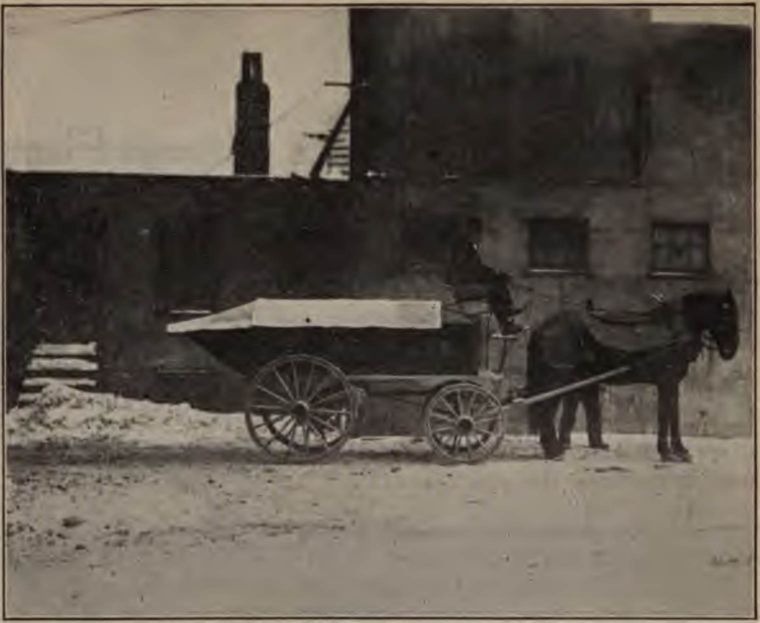


Fig. 2. Collection Wagon with Canvas Cover

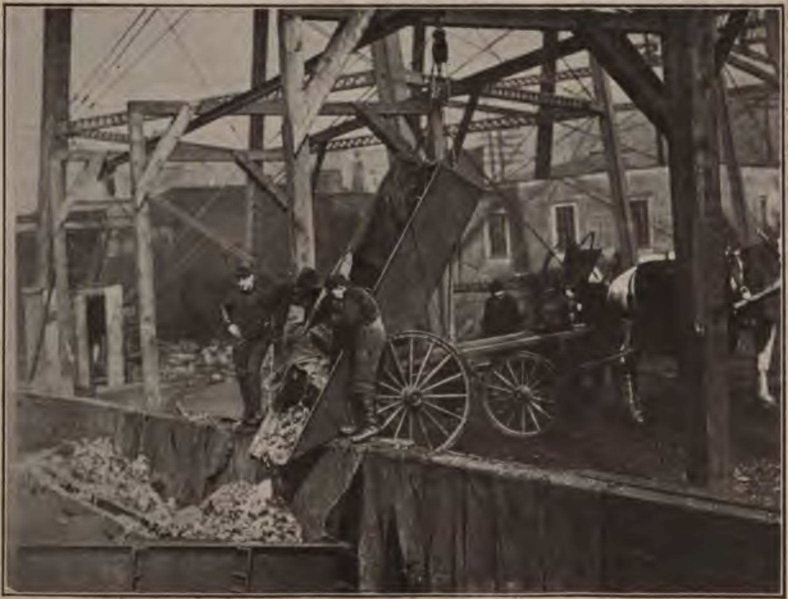


Fig. 3. Dumping Wagon Into Car

The wagons used are of special design (Fig. 2). The box is made of steel, and will hold about 3500 pounds of garbage. It is hinged to the bolster over the rear axle, so that it can be dumped. It is, however, not self-dumping, the purpose being to keep as much of the load as possible to the front of the wagon. In order to dump it, chains are attached to the front of the box, and by means of a triplex block the front end of the box is raised sufficiently to permit the garbage to fall out at the rear (Fig. 3). The wagons are equipped with canvas covers, to hide the material and to prevent the noise usually made by wagons with iron covers.

We also use a special design of railroad car (Fig. 4), of which we have ten. They are constructed of steel throughout. The truck is of standard gauge with 33-inch wheels. The body of the car is a tank 30 feet long and semi-circular in shape. It is supported by trunnions at each end, and also by rollers at three different points underneath. In order to unload the car, cables are passed through underneath the body and fastened at a point about half way from the top, and by means of two 5-ton triplex blocks the body is tipped so that the garbage falls out upon the floor of the receiving building at the works. Their capacity is 40 tons each, and but two men are required to tip them.

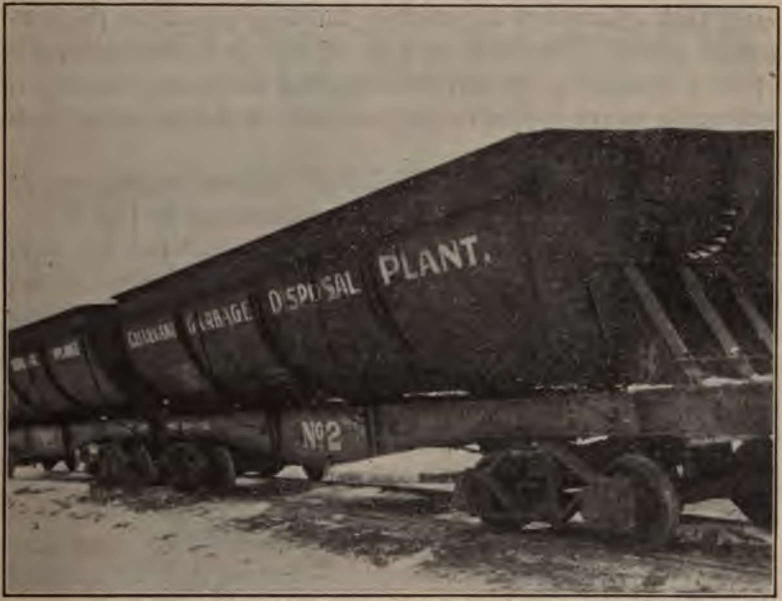


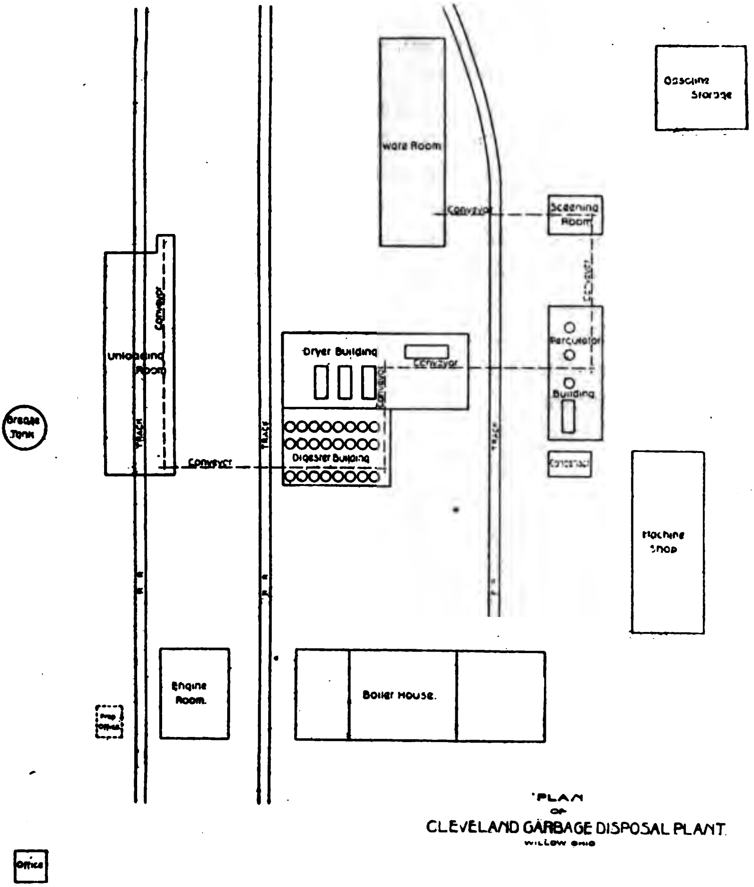
Fig. 4. Special Car for Hauling from Collection Station to Disposal Plant

A general view of the reduction works is shown in the accompanying picture, which I have designated as Fig. 1. The small frame building in the foreground is the office. The one-story brick building is the engine room, with the boiler house immediately adjacent.. The long frame building in the rear of the engine house is no longer in use, and will be razed. This building was used prior to the installation of the new process. The tall steel building, the sides of which are covered with corrugated iron, is the new digester building, in which the garbage is cooked. The brick building at the top of the hill is the receiving building. The railroad cars are run into this building and the garbage dumped upon a concrete floor, from which it is shoveled into conveyors and conveyed up into the digester building. The large tank adjacent to the receiving building is used for the storage of grease. This tank has coils of pipe in it, through which steam is forced, for the purpose of heating the grease, thinning it sufficiently to run through pipes to a tank car placed on the track below.

The ground plan of the buildings, railroad tracks, etc., is shown in the accompanying drawing, designated as Fig. 5.

The boiler plant consists of five 80 h. p. and two 150 h. p. return tubular boilers. A 250 h. p. Monarch Corliss engine, direct connected to a Triumph generator, furnishes the power to operate the works, and separate motors are attached to each apparatus requiring power, thus avoiding the use of main line shafts and belts.

As above stated, the garbage is conveyed from the receiving building to the top floor of the digester building by the use of two conveyors, with 6 x 18 x 24-inch flights. These conveyors were installed by the Jeffrey Mfg. Co. of Columbus, Ohio. They pass through the building in a horizontal position and drop the garbage through tubes directly into the digesters or tanks, where the same is cooked. We have 24 digesters, each having a capacity of 10 tons per day, making the total daily capacity of the plant 240 tons. The digesters are 14 feet high and 54 inches in diameter. When the digesters are filled, steam is turned into the material at a point near the bottom of the tank and the garbage allowed to cook from six to seven hours, 70 pounds steam pressure being used. When the cooking process is completed, the steam is shut off at the bottom of the tank and turned in at the top, the pressure thus produced driving off the free water and some of the grease through a draw-off pipe at the bottom. In order to prevent the material from passing out with the water, a strainer and strainer-plate are used. This mixture of water [illegible] ease is pumped into settling vats and allowed to cool, after which the grease is skimmed off the top. The solids remaining in the digester are removed through an opening in the side of the tank about 12 inches from the bottom and deposited in a small car, which is equipped with a worm conveyor, automatically unloading it into a drag conveyor which takes the material to the dryers. It is first put into a steam jacketed dryer 14 feet long and 5 feet in diameter. This



PLAN
OF
CLEVELAND GARBAGE DISPOSAL PLANT
WILLOW OHIO

dryer has a shaft through its center with paddles attached. As the shaft rotates the paddles lift the material, breaking it up and at the same time evaporating some of the moisture. This type of dryer is equipped with two manholes underneath it, through which the material is dropped into still another conveyor and conveyed to a combination steam and hot air rotary dryer. This dryer was designed by Mr. E. S. Peck, superintendent of the plant. The cylinder of this dryer is 30 feet long, 57 inches in diameter, with a 2-inch space between the inner and outer shell for the admission of steam. There is also a 14-inch steam pipe running through its center. To the sides of the inner shell are attached flights 4 inches in width. These lift the material as the dryer rotates.

The dryer is set on a grade of a ¼-inch per foot, and the tankage (as the material is called) is fed in at the upper end and discharged at the lower, the process being a continuous one. At the lower end of the dryer is a series of steam coils with a blower attached, which forces the air around these coils, heating it to about 230 degrees Fahrenheit. This dry air then passes through the dryer, absorbing the moisture from the tankage as it falls from the flights above referred to.

About 50 feet distant from the dryer building is located the percolator building, to which the material is next conveyed, and where the grease is extracted by the use of naphtha. In the upper part of this building there are three bins for the storage of tankage. Under each of these bins is a tank 8 feet high and 6 feet in diameter, which are called percolators. The material is put in through an opening in the top. When filled, the percolator is sealed and naphtha or gasoline is pumped in at the top and allowed to percolate through the material, being drawn off at the bottom and carrying with it the grease. The grease and naphtha flow to a treating tank in which there are steam pipes, where it is heated sufficiently to vaporize the naphtha and leave the grease in the tank. The vaporized naphtha passes through a condenser, restoring it to its liquid form, from which it flows back to the storage tank, and from which it is again pumped into the percolator. After all of the grease has been extracted from the material left in the percolator, the flow of naphtha is turned off, and in order to recover such of the naphtha still remaining in this material, steam is injected into the tankage, vaporizing and driving off the naphtha. This mixture of steam and naphtha vapor also goes to the condenser and thence to the storage tank. The water produced by the condensation of the steam is drawn off from the bottom of the storage tank.

To reduce the condensation of steam to a minimum, it is first admitted into the tank at a point near the top of the percolator. When the material above this point has been heated and the naphtha vaporized, steam is turned in at about the middle of the tank, and afterwards at the bottom, repeating the process until all the naphtha has been vaporized. The loss of naphtha by this system is about 2½ gallons to the ton of dry tankage. The openings in the percolator, through which the grease and naphtha escape, are covered with perforated plates and pipes designed to prevent carrying the tankage through same. The material is removed both from the side and the bottom of the percolator, placed in a conveyor, and sent to a small building about 20 feet distant, in which it passes through a hexagon revolving screen, taking out rags, tin, pieces of crockery, glass, etc. From here the finished product is conveyed to the storage house and there loaded upon cars for shipment.

The taking out of the material from the above type of percolator and replacing the small perforated plates and pipes through which the grease escapes, involves considerable time and labor. Mr. Peck has invented a new type of percolator, which, I believe, will overcome these objections, and at the same time greatly reduce the loss of naphtha and leave the material much dryer. This percolator is similar in design to his dryer, except that it is but 14 feet in length and 8 feet in diameter. It is placed in a horizontal position, has a steam jacket, and is constructed to rotate in the same manner as the dryer. The material is put into this percolator through two manholes in its upper side. The pipes for the admission of gasoline are also connected through the covers in these manholes. The grease and naphtha escape through three openings in the lower part of the tank, and in order to hasten the process of percolation the pipes can readily be disconnected and the percolator rotated so as thoroughly to mix the entire mass of material with the naphtha or solvent used.

In order to recover the naphtha after the grease has been extracted, steam is turned into the drum and jacket and the percolator made to revolve, thus while heating the material, also moving the same sufficiently to release quickly all of the solvent contained in the tankage. By this method no moisture is added to the material nor steam mixed with the vapors, which go to the condenser and thence to the storage tank. By the use of this type of percolator I think that the loss of naphtha will not erceed one gallon per ton of material treated.

Our naphtha storage building is constructed of concrete, the tanks being placed below the ground level, only the roof of the building projecting above the surface.

In the old process formerly used, the grease was extracted by means of hydraulic presses, the tankage being placed between burlap on racks in layers about 3 inches thick and 5 feet square. The cylinder of the presses was 14 inches in diameter, and subjected to a pressure of 3,500 pounds to the square inch. By this means the liquids were squeezed out of the material, carrying the grease with same to a vat, where, after cooling and settling, the grease was skimmed off.

The tankage produced by this method is not as desirable to the trade as that which we are now making from our new process. There is about 12% of grease left in the pressed tankage, whereas in the other there is only about 2%. The grease being the most valuable part of the product, makes it desirable to recover as large a percentage as possible.

During the year 1907 we collected and reduced 37,606 tons of garbage. The cost of doing the work was $193,365.76. The gross income for sale of product, including inventory of material on hand and miscellaneous revenues, amounted to $136,985.60, leaving, therefore, the sum of $56,380.16 to be charged to taxes.

Prior to 1905 the garbage was collected and disposed of under private contract, the city paying $69,400 per year for this service. On January 1st, 1905, the city purchased from the contractor the reduction works and collection equipment, paying therefor $87,500. At that time the works had a capacity of about 110 tons per day. Our present works has a capacity of 240 tons per day. While we have endeavored to operate the department with as much economy as possible, we have, however, felt that the work of collecting the garbage is of such importance, and has so large a bearing upon the health of the community, that special effort has been put forth to give an improved service.

The city is divided into 67 routes, using in all about 80 wagons and 110 horses. During the last year of the contract (1904) there were collected 24,687 tons. In 1905, under municipal control, this was increased to 30,382 tons. In 1906 the collection amounted to 34,891 tons; in 1907 37,606 tons. At the same rate of increase the collection this year will amount to more than 40,000 tons.

Every effort has also been made to recover a larger percentage of the valuables contained in the garbage so as to secure a greater return from the sale of by-products. The receipts to the city in 1905 from this source amounted to $65,881.14; in 1906 it had increased to $106,990.41; in 1907 to $136,985.60. Not all of this increase is due to the larger percentage of grease and tankage recovered, but in part to better market prices secured for same.

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TRANSACTIONS

The Cleveland Engineering Society

No. 2.

The Cuyahoga Valley Viaduct of the "Nickel Plate" Railroad

By GEORGE H. TINKER, B. C. E.
Bridge Engineer N. Y. C. & St. L. R. R.

Read at the meeting of the Society October 13, 1908.

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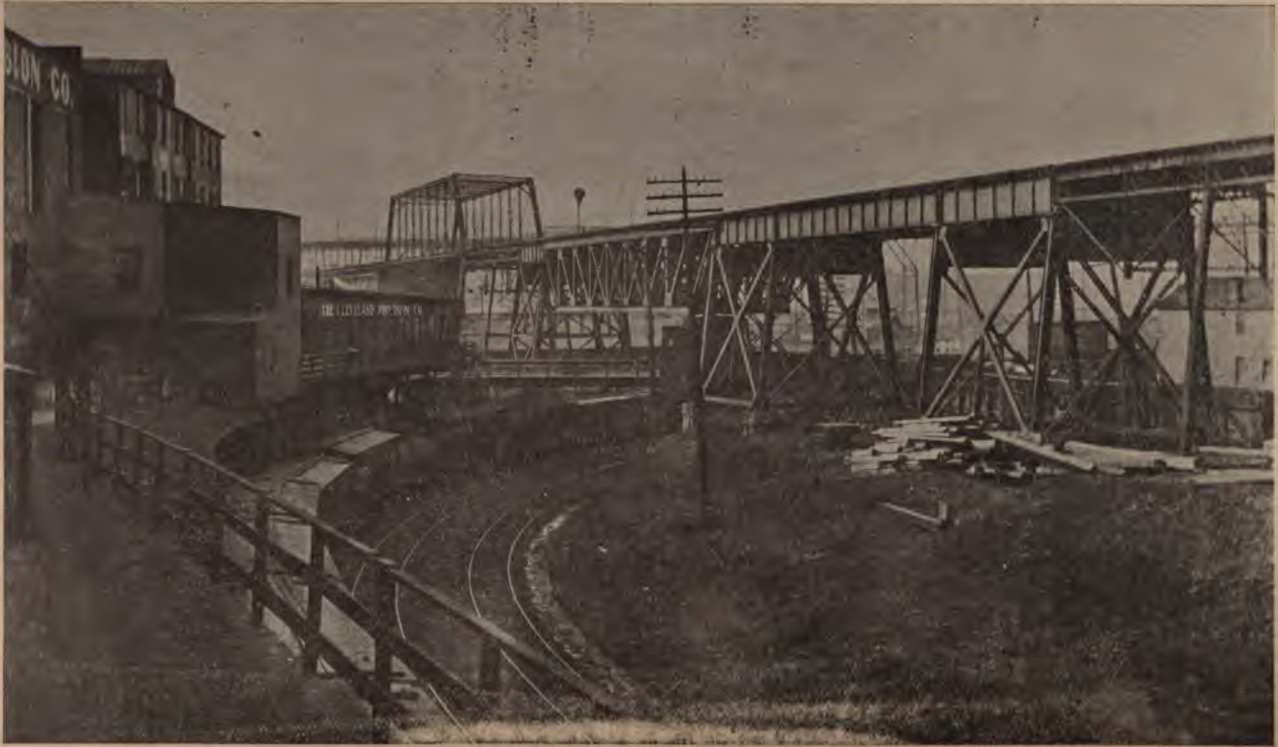


Span over B. & O. R. R. and Canal Road

The Cuyahoga Valley Viaduct of the Nickel Plate Railroad.

By GEORGE H. TINKER, B. C. E.
Bridge Engineer N. Y. C. & St. L. R. R.

The Cuyahoga River flows through a deep and wide valley, in a tortuous channel with unstable clay banks. It forms the inner harbor of the City of Cleveland, and is crossed by many highways and railroads at various angles and different elevations. The New York, Chicago and St. Louis Railroad crosses the valley on a high steel viaduct, in a generally east and west direction, about one and a half miles from the lake. Several highways and railways, lying at different elevations are crossed in the length of the viaduct. At the east end the W. & L. E. R. R. is crossed, which in turn crosses the B. & O. R. R. and the river. A little farther on Canal Road and the B. & O. R. R. are crossed, the B. & O. R. R. also passing under Canal Road, so that the three lines of travel are superimposed one above the other and the railroad bridge above the highway bridge. Beyond the B. O. R. R. the viaduct passes over the Central Way freight house and tracks of the L. S. & M. S. R. R., and West 3rd St. Proceeding West the switching tracks of the Big Four Railroad to the lumber yards are crossed, and the Central Viaduct passes high overhead. The river is spanned by a drawbridge and immediately beyond are the main and yard tracks of the Erie R. R. and lastly University Road.

The total length of steel structure is 3010.5 feet. It is double track throughout, the two tracks being 12 ft. 6 in. center to center. There are three curves upon the viaduct, one three degree and two four degree, the total length of curve being 951.1 feet and of straight track 2059.4 feet. There is an ascending grade to the west of 35/100 per hundred feet. The general elevation of the track above the valley is about 50 feet, and above the ordinary surface of water in the river seventy feet. When the end of the lift bridge is raised to its highest position it is over 260 feet above the bed of the stream below.

The first structure, built at the beginning of the operation of the railroad, was a wrought iron viaduct, and consisted essentially of alternate tower and intermediate spans of the Fink pin-connected type. The various highways and railways were spanned by trusses of different lengths and types, and the river by a pin-connected deck swing span. The total weight of iron was 1661 tons. The substructure was sandstone masonry. The first train passed over the viaduct on August 26th, 1882. The

Chief Engineer at that time was Mr. J. A. Latcha. Mr. W. M. Hughes was Bridge Engineer. The Engineer in charge of substructure was Mr. Wm. H. Boeh, and the present Secretary of the Cleveland Engineering Society staked out the foundations.

The bridge was a good example of the state of the bridge builders' art at that time, and served its purpose well. The locomotives then in use on the road weighed 66 tons. Those in use today weigh 145 tons. With the increased weight of rolling stock weakness of details developed. An examination of the structure prior to its removal showed excessive wear on the pins on account of insufficient bearing area. Also the bracing was insufficient in the light of modern practice. These two defects caused a large amount of vibration and motion at the joints. The material itself was generally in excellent condition. The lower tower struts were an exception. Composed of two channels, they were so placed that one channel held water and dirt. In many cases the web was rusted entirely through. Another detail which showed excessive wear was the bearing of the floor beams on the top chords of the trusses. In many cases the flanges of the floor beams had cut through the cover plate of the chord.

These facts, together with the desire to provide for an increase of load made it desirable to replace the wrought iron structure with one of steel designed for present day rolling stock. The new structure consists essentially of a plate girder viaduct, having alternate thirty-foot tower and sixty-foot intermediate spans. The typical structure is interrupted by the necessity for longer spans at various points, as was the original viaduct.

Reconstruction was started on November 14th, 1904, at the crossing of Canal Road, and the B. & O. tracks. The original structure at this point consisted of skew spans having two deck trusses, and the skew was such that a panel point in one truss came opposite the end post in the other truss. When one track was loaded the deflection of the truss opposite the bearing of the other caused a high stress in the sway rods, which were continually breaking. In the new design four deck trusses are used, one under each rail, with the ties resting directly on the top chord. The span was made 125 ft. 9 in., spanning both highway and railroad. On account of limited headroom over Canal Road the depth of the trusses was made 20 feet. The connections are riveted and the pin-bearing shoes are placed under the top chord, in order to bring the bearing as near the rail as possible and avoid sway. Heavy rigid cross bracing is used at every panel point, and the two inside trusses are tied together at both top and bottom chords with a system of diagonal bracing in a horizontal plane. Top and bottom lateral bracing is used, so that the whole structure is very stiff and entirely free from vibration, but no vertical shear is transferred from one track to the other. The outside trusses are supported upon the column caps, and the inside trusses upon double-web cross girders riveted between the columns. The webs of these girders are 72 inches deep, The expansion ends of the trusses are seated on nests of segmental rollers. Hand riveting was employed upon this portion of the work. The weight of this span is 206 tons.

In order to support the falsework over the B. & O. tracks four 60-foot plate girders which had been built for another job were borrowed and supported upon timber bents at each side of the tracks. Upon these were laid cross timbers and upon them the traveler tracks. To carry traffic during construction pony bents were erected on the level of the traveler run, supporting the stringers under one track. The other track was then abandoned, the old structure removed and the new erected for one track. Ties and rails were relaid and traffic resumed. The second track was then abandoned and the operation repeated. This, in general, was the method of procedure for the entire viaduct. Tower columns were lowered through the falsework and tied up close to their proper location. The track being supported upon the pony bents, and the old floor beams and trusses having been removed, the old columns were swung out and the new ones in, cross girders placed, and as much as possible of the tower bracing bolted up. Track girders could now be placed and the track relaid. The old masonry pedestals were found to be in good condition, and the length of spans was regulated so as to utilize them as far as possible. In some cases the capstone was removed and a new concrete cap placed. To accomplish this a concrete block of the proper dimensions was cast in a form erected by the side of the pedestal and at such an elevation that the block could readily be swung into place and bedded in cement mortar as soon as the old cap was removed. The new cap was then leveled and centered and the new column placed. The steel erection gang and the Company mason gang worked together in making such a change. After the column was set anchor bolt holes were drilled and anchor bolts grouted.

After the completion of this first section, on February 21st, 1905, no further erection was done until the following spring. Work was then started at the east end and prosecuted continuously until the viaduct was completed. The use of the overhead traveler was abandoned and erection handled by means of two self-propelling derrick cars. A pneumatic riveting plant was also installed.

From the east end to the section previously described the structure consists of the typical viaduct construction. The tower columns are built of Z-bar sections and have a batter of 1¼ inches per foot. The outside girders rest upon the column caps, and the inside girders upon a cross girder riveted between the column tops. The girders under each track are spaced 7 ft. 6 in. center to center, and the tracks are 12 ft. 6 ins. center to center. The 30-foot girders are fixed at both ends; the 60-foot girders have one fixed end and one sliding end. In order to simplify the details of the bearings the 30-foot girders are made the same depth as the 60-foot, viz.: 60 inches. The flanges of the 30-foot girders consist of two 5 x 3½ x ½ inch angles and one cover plate 12 x ½ inch; those of the 60-foot girders of two 6 x 6 x ⅞ inch angles and three 15 inch cover plates, ⅝, 9/16 and ½ inches thick. Top and bottom flanges have the same section, but the first cover plate on the top flange is full length. Both 60-foot and 30-foot girders have stiff top and bottom laterals, end frames and intermediate cross frames made of angles. A special effort was made to get rivets enough in a connection to develop the full strength of the angle. Seven-eighths inch rivets were used throughout. The weight of four 30-foot girders and their bracing is 32,000 lbs., and of four 60-foot girders 100,000 lbs. The weight per foot of a single track girder span is given by the formula $W = 10.5\ L + 200$, where L equals the length of the girder in feet. Cross ties are of oak and are 8 inches by 11 inches by 10 feet. They are spaced 14 inches center to center. The location of each tie was marked on the girder, the ties dapped and bored to fit over the rivet heads.

The span over the Central Way freight house is a riveted through truss bridge with two trusses, 141 feet long. It is built on a slight skew with trusses spaced 29 feet center to center. The depth of the trusses is 30 feet center to center of chords. The weight of a double track floor beam is 14,000 lbs. The total weight of the span is 256 tons.

In the erection of this span it was necessary to interfere with the working of the freight house as little as possible; therefore a special arrangement of false work was necessary. There are four house tracks on one side of the house and a team delivery platform on the other side. A bent was erected on the edge of the platform close to the tracks and another close to the house. Bents were placed between the tracks which were spread enough to allow cars to clear. Holes were cut through the roof of the house and bents lowered through. The floor was blocked up under the sills of these bents.

The skew of this span is for the purpose of accommodating the tracks below; this also necessitated the use of a skew tower at the east end. The original construction at this point was rather unsightly because of the combination of skew and batter and the necessity for providing for the wider spacing of the trusses. In the new bridge this feature was avoided by the use of a special design of tower having four plumb posts. The columns in each bent are 29 feet center to center, and the two bents are 24 feet 7 inches center to center on one side of the tower and 33 feet 1 inch on the other side. The ends of the four track girders are supported on the cross girders, and the truss shoes on the column caps. Columns supporting the ends of trusses are of heavy section built up of plates and angles. The columns at the end of this span weigh 16,000 lbs. each.

The west end of the span rests upon the old masonry pier on the line of West 3rd Street. The street is spanned by deck plate girders. The span is squared at the west end, making the girders of different lengths. The short girder is 82 feet 6 inches long, and the long girder is 88 feet 8 inches. The flange of the long girder is composed of two angles 6 x 6 x ⅞ inches and three cover plates 15 x 9/16 inches. The web is 108 inches deep at the center and 84 inches at the west end. The weight of the four girders and bracing is 92 tons.

Beyond this point to the river the regular viaduct construction is continued except at the crossing of the Big Four tracks, where a 120-foot deck truss span is used, similar in design to the span over the B. & O. The weight of this span is 188 tons. At each end are three-bent towers.

There are two curves on this part of the viaduct. The difference in length of inside and outside of curve is adjusted by varying the length of the intermediate girders; the tower girders being maintained at 30 feet. The elevation of the outer rail is secured by fastening blocks on the under side of the ties.

During the erection of this portion of the viaduct a general strike of bridgemen occurred. Efforts were made to dynamite the bridge and several attempts made on the lives of the foreman and others. The work was conducted thereafter under the protection of armed guards.

We have now arrived at the point where trouble begins, viz: at the bank of the Cuyahoga River. The preliminary studies of the situation at this point contemplated the erection of a swing span upon the old center pier. During the year 1905 plans were drawn for reinforcing the old pier to carry a longer and heavier span. Borings were made in the river bottom to determine the character of the foundation. Holes over 100 feet deep showed mud and clay becoming gradually harder from forty feet down. It was decided that a safe bearing of ten tons per pile could be secured, and upon this basis plans were drawn for a swing span 80 feet longer than the old span, which would provide a 120-foot channel each side of the center pier. The new trusses would have been erected outside of the old trusses upon a new drum outside of the old drum, the whole stayed together temporarily and swinging together, thereby maintaining traffic on the river and on the railroad and accomplishing the erection of the new span without falsework. When the new

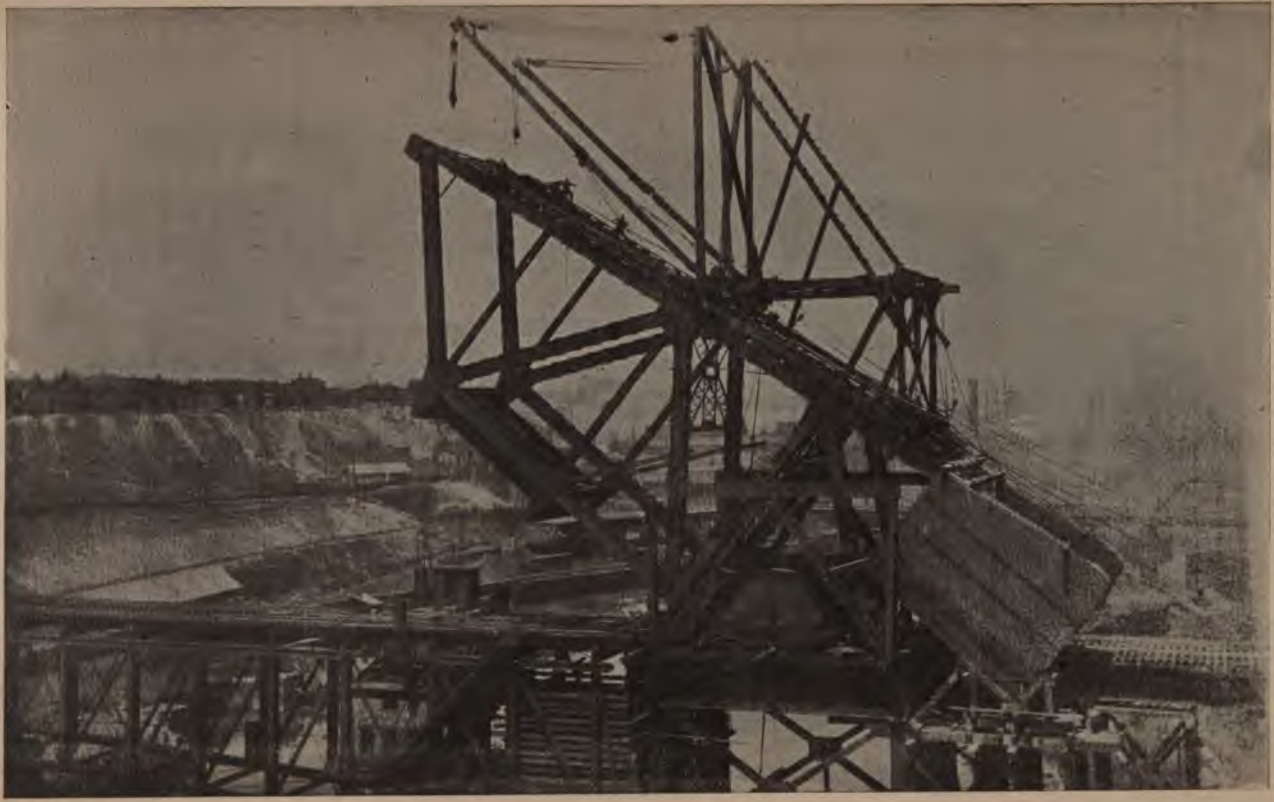
View from West End Showing Old Swing Span

steel reached the end of the old, temporary bearings would be provided and the live load thereafter carried by the new trusses. The old span would then be removed from within the new and the new machinery installed. In the meantime the 40-foot extension on each end would be erected on shore and spliced to the swinging portion simultaneously at both ends, the temporary bearings removed and the permanent ones put into service.

This scheme was the subject of careful study for upwards of a year and seemed to be a satisfactory solution of the problem. Approval of the plans was obtained from the City of Cleveland, the State of Ohio, and the U. S. War Department. Bids were received and contracts let when objection was raised to maintaining the center pier, and the city withdrew its approval. It was then decided to erect a Scherzer rolling lift bridge, placing the free end on the old West river pier, and the rolling end upon a tower standing just east of the old center pier.

In May, 1906, work was begun upon the foundations for the lift pier. A double row of sheet piling was driven enclosing the site, and the space between filled with clay. The construction of this cofferdam was a very difficult piece of work. The soft mud of the bottom afforded a poor hold for the piles, and notwithstanding the sides of the cofferdam were strongly braced with 16-inch timbers, they bulged badly and it was with great difficulty that the water was kept out. On the 6th of December the cofferdam was at last completed and the pit emptied. On the 18th the driving of foundation piles was begun. Excavation and pile driving were carried on simultaneously in different parts of the pit. On the 4th of January, 1907, the pit was flooded by high water. At 4:00 P. M. on the 6th the pumps were started and the pit emptied at 3:00 A. M. the next day. Two feet of silt had been deposited. On the 9th excavation was again in progress, and nine days later the first concrete was deposited. There had been 1448 cubic yards of mud excavated from the pit. As the level of the concrete was raised the timber bracing was removed. Concrete was conveyed to place by chutes from two mixers. The proportion of ingredients was one barrel of cement to 10½ cubic feet of sand and 27 cubic feet of broken stone, making one cubic yard of concrete. The mixture was wet, and salt was added in freezing weather, which was most of the time. Fires were kept burning at night and none of the concrete froze.

The lift pier consists of four pedestals upon a common slab footing, and connected together by four walls ten feet wide on top and thirteen feet deep. These walls are reinforced with eyebars taken from the old bridge. In order to accommodate the skew of the channel the upstream corner on the channel side was cut off and the pier extended upstream on that corner to secure a larger number of piles and equalize the bearing on the foundation. There are 782 piles in the foundation; 204 are under the pedestal carrying the southwest leg of the tower. They are driven to a depth of 35 feet below the bottom of the excavation. The penetration under the last blow of a 3200 lb. hammer, fall-



Traveler on Top Chord of Lift Span

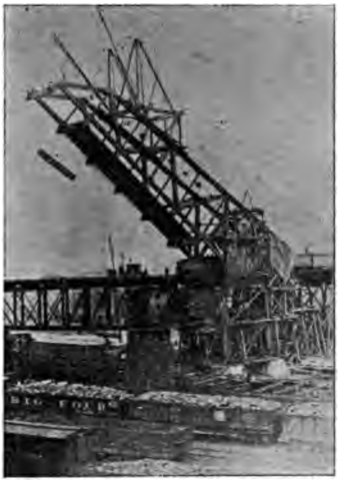
ing 38 feet, was about 2½ inches. The average safe load per pile, computed by the Engineering News formula, is 25 tons. The maximum load that can come on the 204 piles under this corner is 9.85 tons per pile. If there should be any tendency towards unequal settlement, the tie walls, acting as cantilevers, with the rods strained at 16,000 lbs. per square inch will transfer 17 per cent of the load to the adjacent corners of the pier. So far as can be determined after the expiration of a year there has been no settlement whatever. The pedestals are 10 x 15 feet at the top and about 11 feet out of water. Long anchor bolts were built into them for securing the base of the columns. There are 2974 cubic yards of concrete in the pier and its weight in air would be 6,000 tons.

As soon as the pile driver force could be released it was moved across the river and started upon the foundations for the west pier. The conditions were different here, in that the old masonry pier had to be removed and a new concrete pier built in the same place. It has been mentioned that the banks of the Cuyahoga River are unstable. In years past the old pier had moved towards the channel, an experience not unique with the Nickel Plate, and the pier cracked in places, so that it was considered advisable to rebuild it on a deeper foundation. Falsework bents were driven in front and in rear of the pier, and while driving the latter on April 4th the pier commenced to break up and showed signs of collapsing. The top of the pier was removed and some old floor beams placed across the caps of the falsework bents to carry the end of the draw and the fixed span to the west. The work of demolishing the old pier was then continued, while the driving of the cofferdam was in progress. Driving was greatly interfered with by the presence of old piles or snags in the river. On the 22nd of April the old pier was all removed and on the 16th of the next month the sheet piling was driven. The cofferdam was filled with a mixture of 1½ parts of clay and one part of gravel, with some straw and hay. Some material was also dumped outside the cofferdam.

On the 3rd of June a vessel going upstream was unable to make headway against the current and stuck with her stern opposite the cofferdam for several hours. The current set up by her propeller in the violent efforts made to extricate herself scoured the channel to a depth of 28 feet. When the pumps were started the next morning the dam leaked badly. The leak was stopped by a mixture of clay and fine manure. As the water was lowered in the pit leaks developed from time to time, but could always be stopped by the use of the clay and manure mixture. Vessels struck the protection piling outside the cofferdam frequently, breaking the bracing and causing a great deal of damage. On one occasion a falsework bent was knocked out of plumb and the men hastily left the work for fear the whole bridge would fall into the pit. It was noticeable that certain pilots always hit the protection and others never did.

During this month excavation was in progress, and in July the foundation piles were driven. There are 155 piles, about the same length as on the other side of the river. The driver leads had to be shortened in order to get under the falsework, so that the fall of the hammer at the last blow was 25 feet; with a 3200 lb. hammer, the penetration was 1½ inches. The average safe load per pile, figured as before, is 34 tons. There were 669 cubic yards of material excavated. Concreting began on August 4th. The pier is of rectangular form, but having the downstream corner on the channel side cut off slightly. There are 1,444 cubic feet of concrete, and a number of old eyebars and rods are embedded, both horizontally and vertically.

On account of the falsework and the old draw the pier could not be finished to the level of the bridge seat. Two large blocks of concrete to carry the bearings of the lift and adjacent span were therefore cast and conveniently placed where they could be picked up and swung into position by a derrick car when the change should be made. Forms were then built for the top of the pier and the blocks concreted in. This method of completing a pier has been adopted several times and permits a satisfactory job.



Erecting Last Panel of Lift Span

On the 30th of April four panels were cut off the end of the old swing and a sand box built into the shortened arm to act as a counterweight. The lift tower could now be erected without interfering with the swinging of the draw. The tower consists of four heavy columns capped by two double-web girders, which carry the tracks upon which roll the segmental girders. The lift was erected in the raised position, at an angle of about 35 degrees. The first floor beam and panel of stringers were omitted, permitting trains to pass through. As soon as the trusses were erected as high as the derrick car could reach a long-and-short legged traveler was erected upon the top chord, and moved up the chord as the erection progressed. The segmental girders were kept blocked, and counterweight was added from time to time to keep the span balanced. The alignment of the trusses was regulated during erection by the use of a transit, so that when the lift was lowered to a bearing on the rest pier there was no troublesome error to correct.

The motive power is electricity, applied through two 52 H. P. alternating motors, 60 cycles, 3 phase, running at 560 revolutions per minute, and using current at 440 volts. Only one motor is used at a time, the other being held as a reserve. The motors are mounted upon a machinery deck, above the track and move with the bridge. The operating house is supported upon brackets at the side of the tower.

Besides the switch board, controllers and indicators the house contains a gasoline engine for auxiliary or emergency use. Motion is transmitted through gearing and shafts to the main driving pinion on the machinery deck. As the machinery deck moves and the engine is fixed the difference in the relative position of the two is accommodated by an arrangement of shafts and gears which allows a shaft to slide through one pinion as the distance between the pinions at each end varies. The operation of the bridge by either power is perfect. The time of operation, to open or close is about 1½ minutes by electric motor and 14 minutes by gasoline motor. There are solenoid brakes on the motors and a band brake in the operating house for use with the gasoline engine. With these brakes all off the bridge will stand at any angle.

The ties and rails were fastened upon the lift, except the first panel, before it was lowered into position. The machinery was put into commission and the bridge operated as far as possible to see that everything was in smooth working condition.

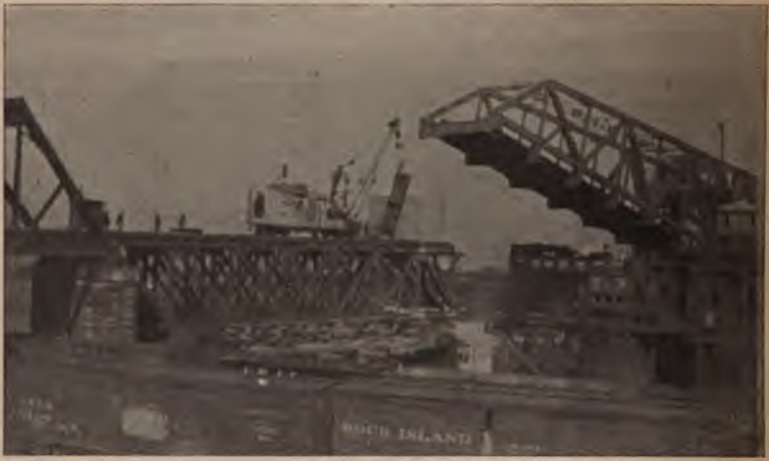
The length of the span is 162.5 feet and the clear channel between protection piling is 120 feet. The weight of the movable span is 521 tons. The counterweight is 638 tons of which 90 tons are pig iron and 548 tons are concrete. The weight of the tower is 348 tons.

While the river portion was being erected the three spans west of the river were also under way so that the final connection was made at the west river pier. The span next west of the river is a 120-foot deck truss span with four trusses, essentially similar to the 125-foot span previously described. Its weight is 228 tons. It was erected on falsework in the usual manner. West of this is a 120-foot through riveted span with two trusses spaced 30 feet center to center. The trusses are 30 feet deep. The span is upon a curve and the elevation of the outer rail is accomplished by framing the stringers at different elevations. Both of these spans are over tracks of the Erie Railroad, and are supported upon the original masonry piers except at the west river pier. The weight of the through span is 231 tons.

The west span of the bridge is a 103-foot through plate girder span over University Road. There are two girders with 120 inch webs, spaced 30 feet 6 inches center to center. The flanges are composed of two angles 8 x 8 x ⅞ inches; two side plates 16 x 11/16 inches and four cover plates 22 x ¾ inches. The girders have pin-bearing shoes. The floor beams are of built I section and have large gussets riveted to stiffener angles on the web of the girder. The stringers are rolled I beams, and are framed at different elevations as in the previous span. The end stringers of both through span and through girders are carried at their shore ends on stringer struts, and these struts have bearings on the bridge seat under the end of each stringer. The weight of the girder span is 211 tons. Each girder was shipped riveted up and erected by means of gallows frames at each end.

Placing Cap Stone on Pier

On the morning of October 19th, 1907, the old draw was swung for the last time. As this was 25 years and 6 weeks since the first train passed over, it was clearly entitled to membership in the Nickel Plate Veterans' Association. Falsework had previously been erected on the protection pier to receive the old draw, and the work of dismantling immediately begun. Traffic was abandoned for the first time during the reconstruction of the bridge. A derrick car was run out to the end of the deck span and the concrete blocks for the bridge seat previously mentioned hoisted and bedded in position on the pier. These blocks are at the level of the lower chord of the deck span, and the masonry of the pier stops at this point. To receive the bearings of the free end of the lift, which are at the level of top chord of the deck span, massive steel columns were built, forming a bent on the pier and weighing 18,000 lbs. each. In the attempt to place the first of these a distressing accident occurred, which marred the completion of the work and turned a day of great satisfaction into one of gloom and sorrow. The overturning of a derrick car, when about to lower a column, resulted in the death of three men, J. S. Yates, the foreman in charge of the erection; F. T. Diehl, trainmaster, and a watchman. Mr. Yates was well known as a bridge erector of more than ordinary ability. He had erected many of the new bridges on the Nickel Plate, and had been in active charge of the erection of the Cuyahoga Valley viaduct from the start of reconstruction. This was perhaps his largest single piece of work, and it is one of the ironies of fate that the day that was to have seen the last link erected should have been his last upon earth. This accident delayed the erecting of this connecting portion until the next day, the 11th of October, 1907, upon which day the first train passed over the new structure.



Derrick Car Handling 9-Ton Column

The weight of the completed structure is 4,913 tons, three times the weight of the old, and it had taken practically three years to reconstruct. During all this time, except about 36 hours, while changing the draw, traffic had been maintained continuously.

The specifications under which the viaduct was built call for a load on each track of two 136-ton locomotives followed by a uniform load of 4,000 lbs. per foot. The steel used is of the grade known as structural steel, having an ultimate strength of 56,000 to 64,000 lbs. Rivets are of a softer grade, known as rivet steel, having an ultimate strength of 46,000 to 54,000 lbs.

The unit stress used is 7500 lbs. per square inch, modified by the proportion $\left(1 + \frac{\text{Min.}}{\text{Max.}}\right)$. The minimum thickness of material is ⅜ inch, except for fillers and lacing bars. Cast steel is used only in machinery parts, shoes and pedestals being built of rolled steel. No cast iron is used. The appearance of the structure is massive. The distinctive features are stiff riveted members, stiff bracing and full riveted connections.

The entire superstructure was manufactured by the King Bridge Company of Cleveland, of which Mr. Harry Fuller is Chief Engineer, and to his skill and attention to details is due, in large part, the satisfactory character of the structure. The erection was handled by the Pittsburg Construction Company. To their careful management is due the freedom from interference with traffic, the successful conduct of the work, and the excellent character of the workmanship. Mr. A. J. Himes was Bridge Engineer of the Railroad during the planning and design of the work. The substructure work was done by the Company forces, under Mr. E. E. Hart, Chief Engineer. The writer's connection with the work began with the erection of the first portion, and a large part of his attention thereafter was occupied by the inspection of the materials and workmanship, and the oversight of the erection.

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TRANSACTIONS

No. 3

The Cleveland Engineering Society

No. 3 April, 1909

TRANSACTIONS

The Cleveland Engineering Society

Ore Handling Machinery at the N. Y. P. & O. Docks.............H. E. Scott

(Read at the meeting of the Society April 14, 1908)

Railroad Location Practice..Willard Beahan, C.E.

(Read at the meeting of the Society November 10, 1908)

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Ore-Handling Machinery at the N. Y. P. & O. Dock at Cleveland, Ohio.

BY H. E. SCOTT.

I. RIVER AND HARBOR.

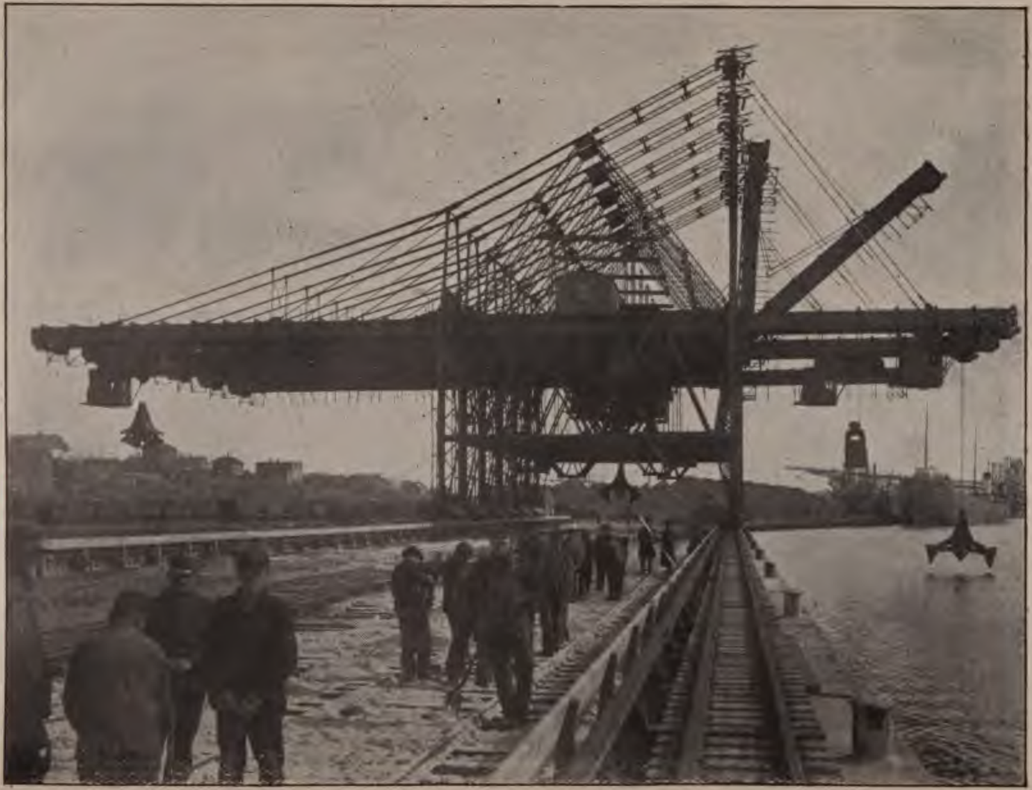
The plant referred to is located near the foot of West 25th St., on the old river bed. It is only 4,000 ft. measured along the bed of the river, from the pier lights to the new unloaders; yet a boat entering the harbor with full cargo would consume from half an hour to an hour in covering this distance. Two steam-tugs are required to tow and guide the vessel up the narrow, crooked channel, since deep-draught vessels are not allowed to use their own propellers in the river, on account of stirring up the mud, and causing shoals.

The channel depth ranges from 20½ to 25 ft. maintained by dredging; and, as the ore-carriers draw from 19 to 19½ ft. of water, there is not much depth to spare.

The width of the channel does not exceed 200 ft. Where the channel is straight, this width allows of mooring one 10,000-ton carrier of 54 ft. beam, on either side, and towing one vessel between them.

None of the ore boats coming into Cleveland has less than three bridges to pass after entering the harbor.

The N. Y. P. & O. dock is attractive in this respect, offering the minimum number of obstructions. Ore docks farther up the river, especially those beyond the Superior St. Viaduct, are at a disadvantage; for example: Corrigan and McKinney's dock, 9,500 ft. from the pier lights, is reached by a carrier in an hour and a half, or more. The winding basin beyond the Jefferson St. bridge, 25,000 ft. from the pier lights, is from 3 to 6 hours up the river. From the foregoing it will be seen that boats lose much valuable time, along the river, which would be saved if the receiving docks were more favorably located. For example: by saving 6 hours on each of 20 trips during the season of navigation, a carrier would have five days to the good, at the end of the season, which would probably enable the owner to send her on an extra trip, thereby increasing her tonnage five per cent.



Unloaders at Fairport, O. on concrete dock

Comparing our harbor facilities with Conneaut, we find that there they unload the largest cargo in the time that the same boat would consume along the Cuyahoga River, in getting into Corrigan and McKinney's dock and out again.

The Conneaut channel is short and straight; fully as wide and deep as our river, and without a bridge to hinder the passage of boats.

II. DOCK CONSTRUCTION.

The N. Y. P. & O. dock is of pile and timber construction. The part on which the new unloaders stand was rebuilt early in 1907, while the unloaders were being erected.

The piling consists of (1) a front row of 45 ft. piles, (on the face of the dock), spaced 10 ft. centers; (2) a tight row, (sheet piling) 12 ft. 6 in. back from the water front. This is made of 3 layers of 4 x 12 x 25 ft. long.

Directly in front of the tight row, and separated from it by a 6 x 10 stringer, is a row of 40 ft. piles, spaced 2½ ft. centers.

(3) Under the front unloaders track is a triple row of 40 by 45 ft. piles, spaced 2½ ft. centers, in each row. A similar triple row supports the rear unloader track, 51 ft. back from the front of the dock.

(4) Mooring piles are spaced 50 ft. centers, and 50 ft. long, along the front of the dock.

(5) The capping is 12 x 12 timbers. The stringers carrying the unloaders are 12 x 16, and the track rails 100 lbs. per yard.

Horizontal anchor rods 2 in. in diameter and about 6 ft. below dock level and 52 ft. long, tie front and back runways together every ten feet.

The maximum wheel load running on this foundation is 52,000 lbs. The maximum static wheel load is 62,000 lbs., about 15,000 lbs. of which is due to 30 lb. wind.

The timber in this dock is about 2,000 ft. board measure, per lineal ft. of dock.

The first cost of a pile and concrete dock, designed for carrying the same loads, such as used at Fairport and Conneaut, would be from 12 to 15 per cent more than for the timber dock.

III. TRACK ARRANGEMENT.

The larger part of the ore received on the N. Y. P. & O. dock is shipped direct to the furnaces in cars. Storage space is limited, and confined to the far end of the dock; the principal business during the season of navigation being the unloading of ore directly into cars, weighing and shipping. The tracks are laid out with this end in view. A double-track spur of the Erie R. R. leads into the dock, at the N. E. end, running along the rear, where the weighing scales are located, to a dead end. From this spur sidings are led off, parallel with the water front, and covering practically all the available space.

There are seventeen parallel lines of track, directly back of the new unloaders, and three lines running under them.

Three hundred seventy-four cars, loaded and weighed out, is about the daily output during the busy season.

Eight hundred empties have been stored in the yard at one time.

The electric unloaders are designed to straddle three lines of track at the front of the dock; the empty cars coming along these tracks from the sidings pass under the unloaders. The loaded cars pass out in the same direction, then, reversing their course are switched back to the spur.

IV. SYSTEM FOR HANDLING CARS.

On the track system just described the cars are handled principally by yard locomotives; ample clearance being provided under the unloaders.

There is also a car-haulage system, designed to move cars on the three front tracks. This system consists of two endless cables of 1⅛ in. diameter, electrically driven by the "Walker differential" drum arrangement, which is driven by a 35 H.P. motor. The cars are hauled by means of a hand grip, which the operator attaches to the continuous running cable, and hooks on to the car, releasing the grip when the car reaches the desired point.

The speed of the cable is about 125 ft. per minute. The cable runs from the haulage house the length of the dock to a 6 ft. bull-wheel and returns; thus providing a means of moving a car in either direction.

Near the haulage house is a bull wheel on a carriage around which the cable passes. Initial tension in the cable is maintained by a counterweight suspended in a tower at this point, and pulling against the carriage.

Where the dock front deviates from a straight line and the tracks are curved, deflecting sheaves are used for the cable; as is also the case where it is necessary to pass under tracks at turnouts. Horizontal, wooden rollers are used to support the cable every 20 ft. at a height of a few inches above the dock level.

The haulage system has not given entire satisfaction. In the opinion of the writer the trouble is due partly to an excessive number of curves, and consequent deflecting sheaves, and partly to the too high speed of the cable, which gives an excessive pull in starting a car.

The present system does not ordinarily supply enough cars to develop the full capacity of the unloading machines.

V. POWER HOUSE.

The power house, which was built during the winter of 1906-7, is a brick building, with steel roof trusses, about 100 ft. by 80 ft. with a brick stack.

The house is divided, longitudinally, by a brick partition, which separates the boiler-room from the engine-room. Coal is supplied from a track running parallel with the length of the boiler-room, and about 7½ ft. above the level of the boiler-room floor. The track is just outside this building.

The coal cars are unloaded here, by hand, and the coal is rehandled by hand to get it to the boilers. About 6,000 tons of coal were used in running this power-house in the season of 1906-7.

The boilers are Stirling, equipped with chain grates, which are of the Green Engineering Company's make. These boilers supply steam for operating the Hoover Mason unloaders, but, primarily, are for running the electric plant, which at present consists of 3-350 kilowatt 250 volt generators, each direct connected to a Buckeye engine. Space in the engine room is provided for a fourth unit, but at present 2 units are sufficient for the usual work.

The electric power is used for operating the 4 Brown Hoist electrical machines, and for the car haulage system, and for electric lights on the dock. All the unloading machinery is used day and night during the busy season.

When running 2 units, the power-house circuit-breaker is set at 4,400 amperes. When 3 units are required, the circuit-breaker is set at 6,000 amperes.

VI. THE ELECTRICAL UNLOADERS.

Each machine has a guaranteed capacity of 300 tons during the first hour's work, in full hatch.

Ninety-five per cent of the cargo can be unloaded without men in the hold of the boat. (This applies to modern boats with wide hatch openings 24 ft. centers.)

Each machine is capable of unloading a hatch complete, with the assistance of five men in the hold, in 3½ hours.

Main Dimensions.

The machines are designed for a working-hoist of 52 ft. 6 in., the lowest position of the bucket being about 21 ft. below the dock level.

In its highest position, the bucket clears the top of a 200 ton weighing-bin, into which it dumps.

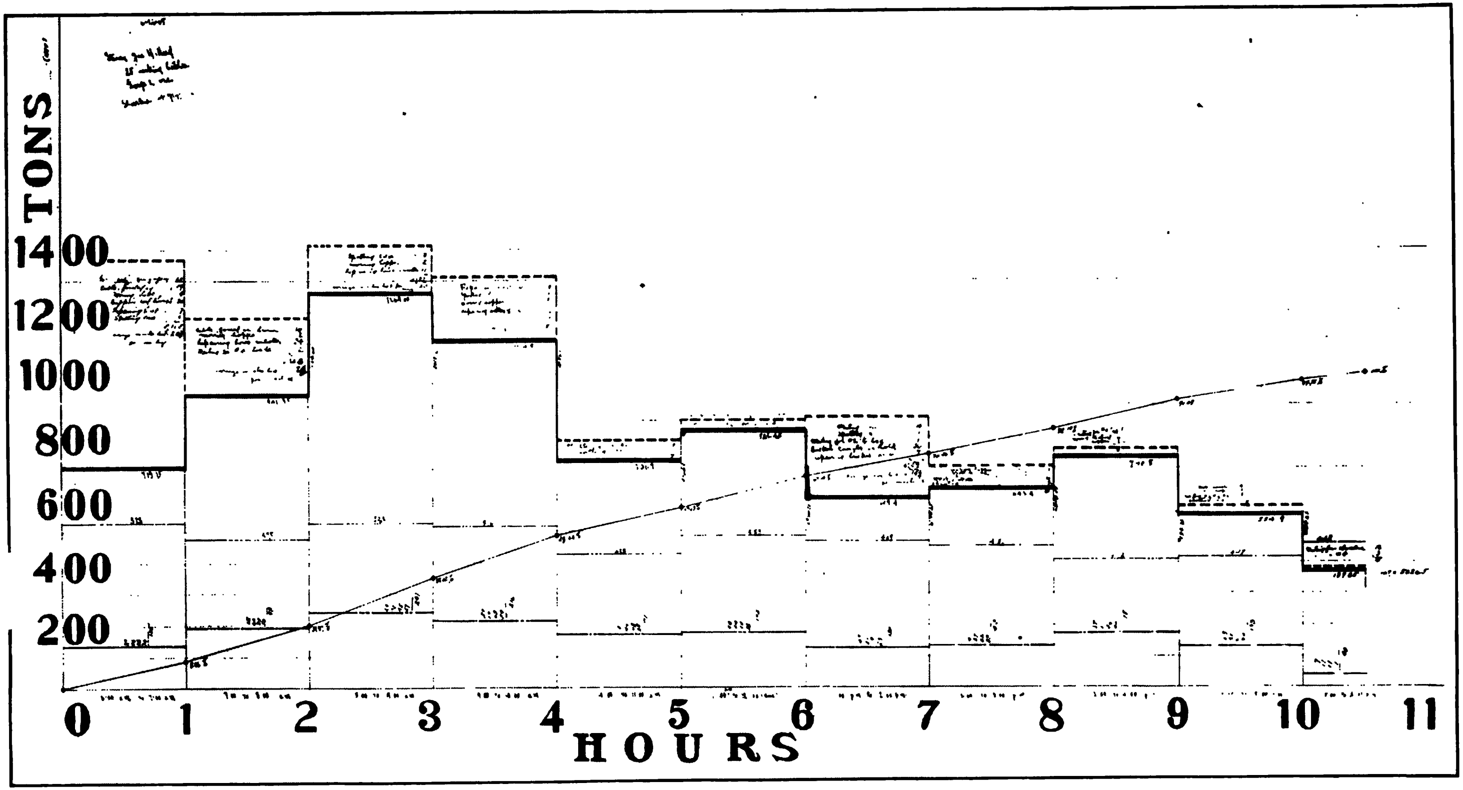
The height of the bin is such as to give 16 ft. clearance for cars and locomotives passing under it.

As previously stated, the unloader straddles 3 tracks, running as close as possible to the front of the dock. The ore, however, is drawn from the bin into cars on the central track, only.

A 60 ft. apron, designed to be raised and lowered over a boat of broadest beam, together with a fixed track over the bin, pro vides a total trolley travel of 92 ft.

The height of the structure resulting from these conditions is 110 ft. to the top of the apron latch on the mast head.

The overall width of the machine is slightly less than 24 ft.; the machines being designed to work 24 ft. center to center; which



Record of 4 Unloaders on the Jas. H. Reed. Areas below the heavy zig-zag line show tons unloaded. Areas above the zig-zag line show delays expressed in tons. Percentage curve from 0 to 100. Bucket average in tons shown on upper light zig-zag line. Number of trips shown on lower light zig-zag line is the standard distance between hatches on many of the lake boats.

From the foregoing it will be seen that the structure is high in proportion to its width; and that more than half its trolley travel overhangs the water.

With the bin full of ore, the approximate weight of one unloader is 450 net tons. With the bin empty the weight is reduced one-half.

The moving load, on the bridge, is about 84,000 lbs.

Under working conditions, therefore, the position of the center of gravity of the whole plant would change considerably; and for the condition with bin empty, and trolley and load in extreme position over boat, the center of gravity would be so near the front of the dock, as to make the plant unstable.

This condition is obviated by using a counterweight on the rear sill, which is sufficient to insure stability under the worst conditions of wind-pressure and overhung live load combined.

The speeds of the various motions of the machines are as follows:

Bucket Hoist—300 ft. per minute.
Trolley-travel—800 ft. to 1,000 ft. per minute.
Bridge travel—50 ft. to 75 ft. per minute.
Apron Hoist—about 2 minutes.

Drawing ore from the bin; a car load in 20 to 30 seconds under favorable conditions.

Motive Power.

Bridge travel and Apron Hoist—75 H. P.
Hoist Motors—2-150 H. P.
Trolley travel—1-100 H. P.
Turntable—1-3½ H. P.
Bin Gates—1-25 H. P.

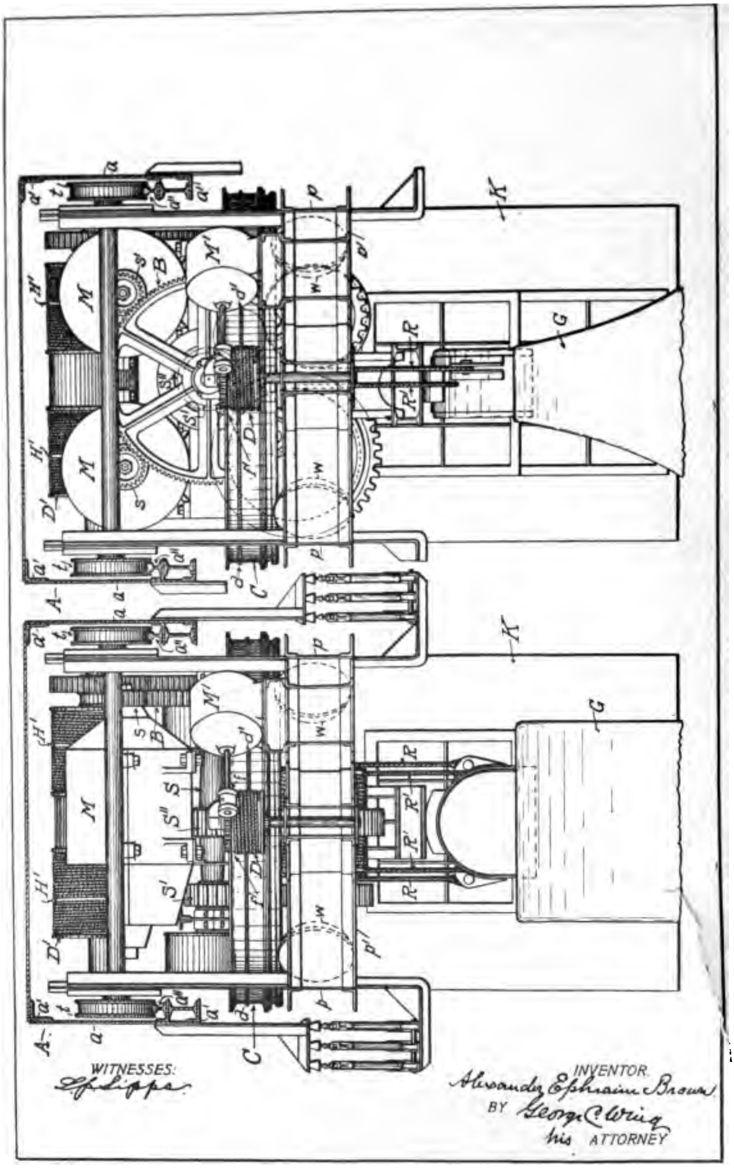
The voltage at the machines is nominally 220 volts.

The amperes passing motors under working conditions are as follows:

Hoisting.................................
peak—1200
average—640
Racking trolley............................
peak—600
average—360
Dumping.................................
peak—520
average—340
Return racking to boat........................
peak—580
average—300
Lowering bucket...........................
peak—520
average—340

This is for a 60 second cycle (one round trip), performing each motion separately.

The average current used per machine, performing each motion separately, and making one trip per minute, would be about 400 amperes.



Front elevation of trolley showing bucket in position for entering hatch of boat.

Front elevation of trolley showing bucket and turntable rotated at 90°

In actual practice the operators combine the different motions: especially the hoisting with the trolley-travel; and the lowering with the trolley-travel; so that the current used is more than as above stated, and the time of a round trip is sometimes reduced to 35 seconds, under the most favorable conditions.

Bucket.

The bucket is the 2 rope grab, of 70 cubic feet capacity, having a spread of 14 ft., and a width of 5 ft. The closing ropes have a purchase of 3 to 1. The sustaining ropes are attached directly to the shell, having no opening power.

The weight of the ore picked up by the bucket varies widely, ranging from 15,000 lbs. per trip, in the soft, heavy grades of Group ore, to less than 6,000 lbs. in hard, lumpy grades. The bucket average also varies, with the percentage of cargo unloaded. For example: Taking a series of 51 boats, the percentage of cargo unloaded was 36.08% ; the remainder being unloaded by other machinery; and the average weight of ore per bucket was 4.37 tons.

From a series of 30 boats, the percentage of cargo unloaded was 75.8% ; the remainder being unloaded by other machinery.

The average weight of ore per bucket was 4.00 tons, showing that the bucket average decreases as the percentage of cargo unloaded increases.

The same thing is shown by observations made at different stages during the unloading of the same cargo. For example: during the first hour in a certain boat 13% was unloaded; the bucket average being 5 tons. During the tenth hour, 4½% was unloaded, the bucket average being 2 6/10 tons.

Trolley.

The main features of the trolley can best be seen by referring to the accompanying cuts.

The motions of the trolley and bucket, as well as the bridge-travel and apron hoist, are under separate control, one operator having all the necessary levers and controllers within reach, from his position in the cage.

The motors, and mechanism for hoisting, racking, and rotating are also carried on the trolley.

Bin.

The 200 ton ore bin is rectangular in plan, 27 ft. 4 in. by 18 ft. 6 in. Its sides and ends are curved, (being of the bag-plate contsruction).

The bin is suspended at each of the four corners by 2-2¾ in. round rods, the maximum corner load being about 130,000 lbs.

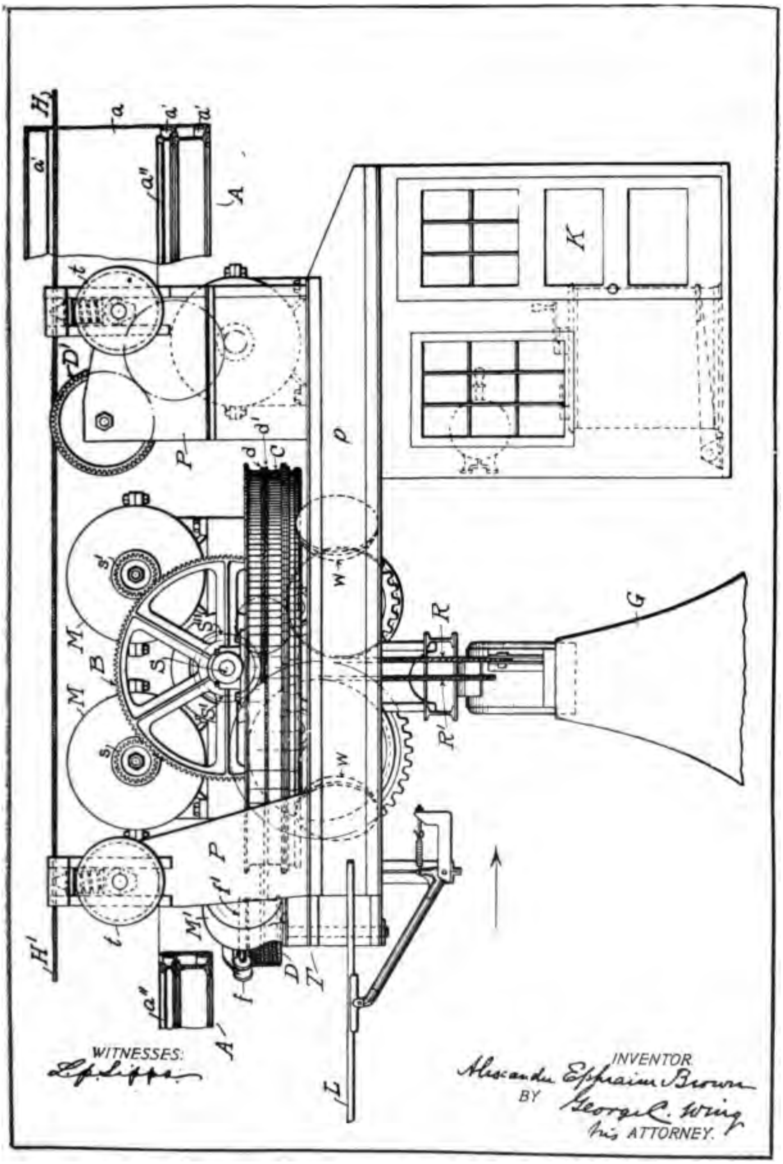
In the bottom of the bin are two chutes, each opening 2 ft. by 7 ft. The gates on these chutes are arranged to operate simultaneously, and draw ore into the same car. The slope of the end plates at the flattest point is 45° with the horizontal; and the slope of the side plates is 40° with the horizontal.

This means that the valley slope is 33°, with the horizontal at the flattest point.

The valleys are too flat, especially for a bin with gates; i. e.

where the ore is likely to stand, and become packed together for 24 hours or more, before being drawn out.

The arrangement of the plant is such that the bucket often rests on the ore, packing it down in the bin. The bin is suspended

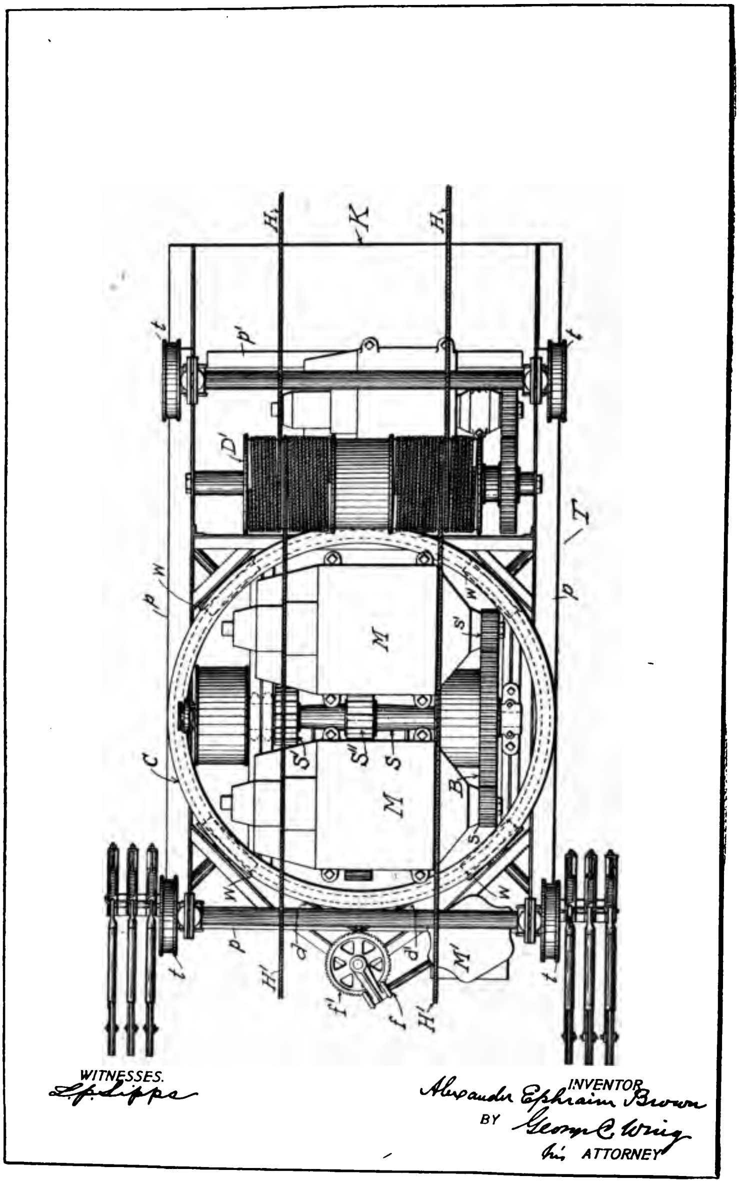


Side elevation of trolley showing bucket in position for entering hatch of boat.

from scale beams, in such a manner as to weigh the ore as it is drawn out into cars; one operator having control of the gates, and of the scale beams.

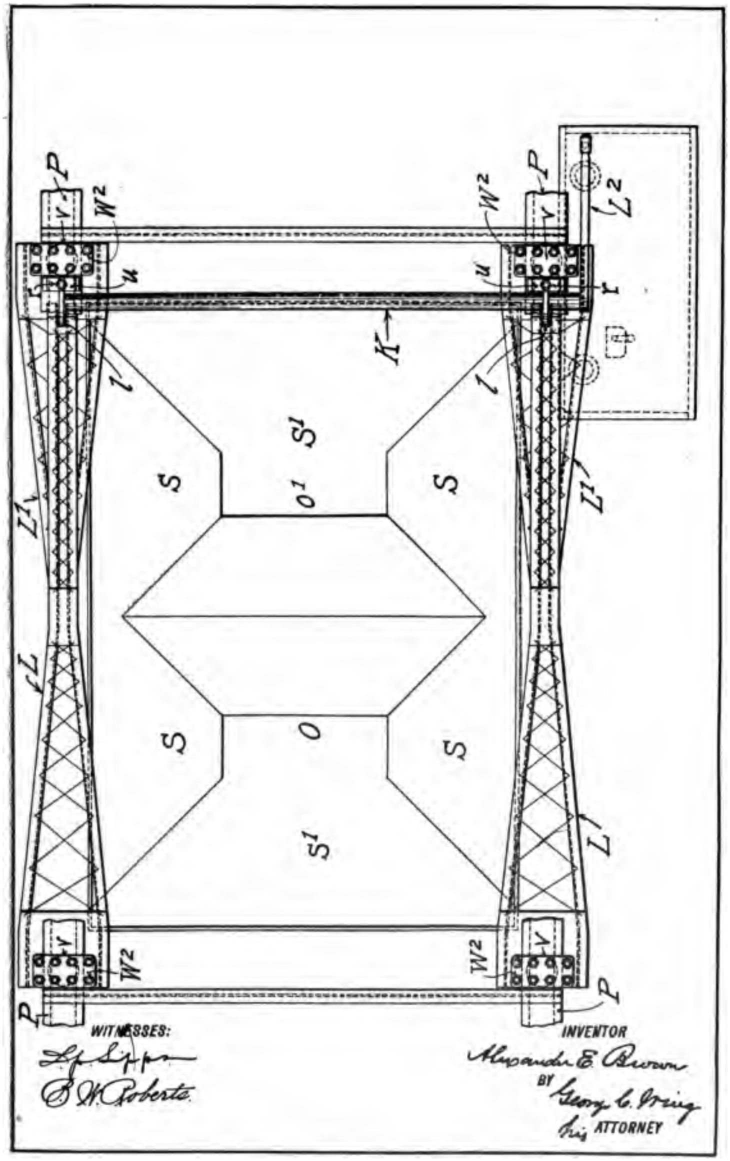
The weighing feature has proved to be very satisfactory, doing away with the need of yard scales, trimming machines, and car-guessers. This means a great saving of labor.

A saving of freight is also accomplished by weighing direct into cars. The railroad company allows a 10% overrun, on the capacity of each car. The scale operator has a list of capacities and over-runs, before him, and loads his cars to the limit. The



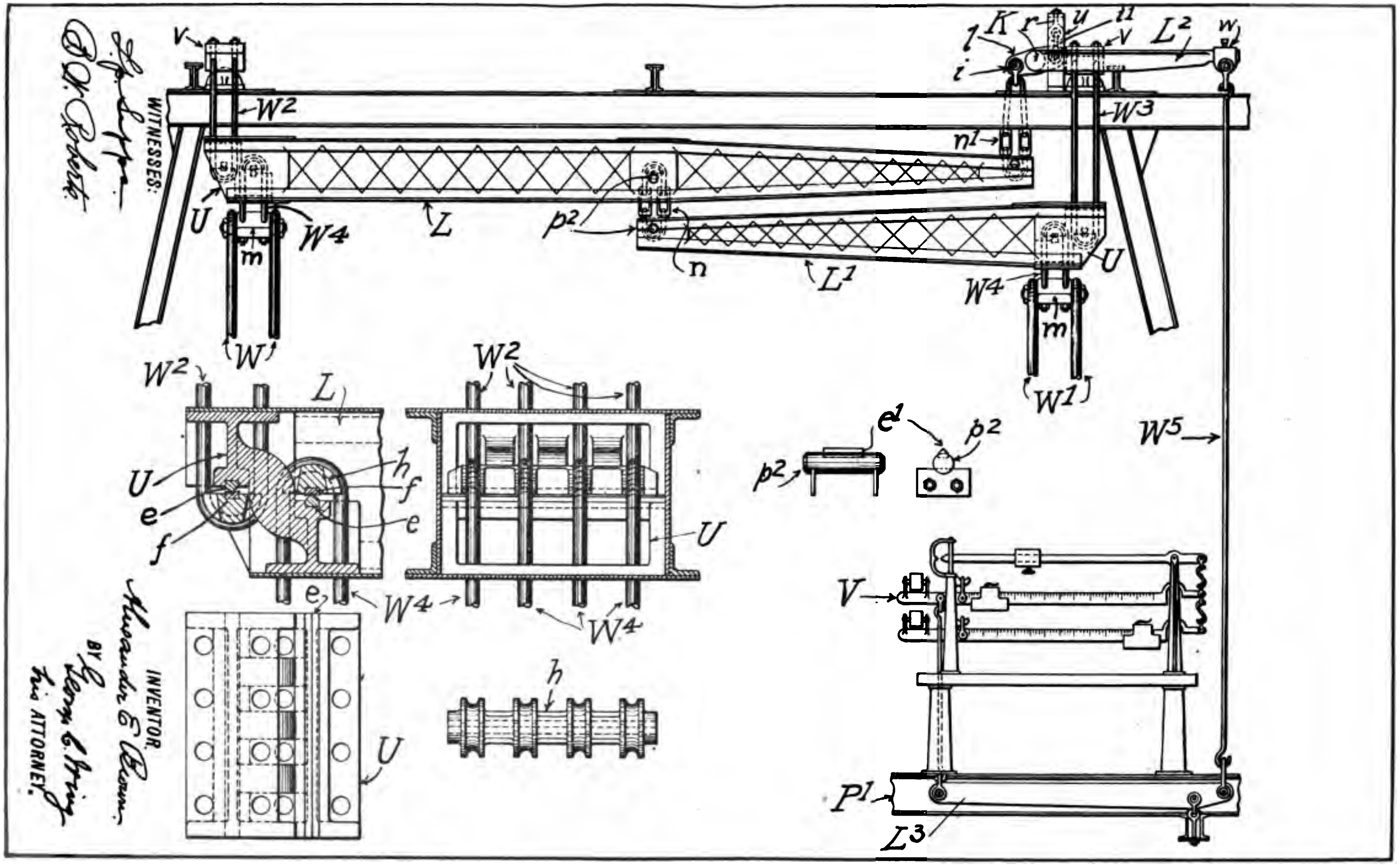
Plan view of trolley

weighing feature is sure to become a part of the ore-unloader of the future; but the requirements of unloading on to several tracks will probably develop a movable weighing-hopper, holding about a car load.



Plan view of bin and scales.

The 16 ft. head room under the gates, which is provided in the case of the fixed bin, would not be necessary in the case of a movable hopper; as the hopper can be moved to one side when a locomotive passes under the unloader.



Details of scales

Where the cable haul is used for handling cars on the front of the dock, a clearance of 11 ft. under the hopper gates would be sufficient for the largest ore cars.

Scales.

The scale beams from which the ore-bin is suspended, are of special design, having been designed and built by the Brown Hoist Co. These beams are built of structural shapes. The main knife edges, which carry a load of 132,000 lbs. each, are made of tool steel, tempered to a hard, cold chisel temper, and ground to a sharp, 90° edge. The length of the knife edge is 24 in.; the pressure per lineal inch being 5,500 lbs.

The knife edge was originally made in one piece, but it was found that the tempering caused it to warp so badly that it was finally cut into three parts, each about 8 in. long.

The knife edges are supported in steel castings which are securely riveted to the structural beams.

The scale beams are hung from four ball and socket connections, provided in the structure of the unloader.

Multiplying levers connect the scale beams just described, with a special set of scales built by Fairbanks, Morse & Co.

These scales have a double beam arrangement, called the plus and minus beams. To draw out and weigh a certain amount of ore, the scale operator first sets the minus beam on zero, and balances the plus beam. This shows the amount of ore in the bin. He then sets the balance weight on the minus beam at the weight to be drawn out, and opens the gates. Watching for the motion of the beams, he closes the gates at the proper time, and if the beams do not exactly balance, he balances them by moving the balance-weight on the minus beam, which then reads the exact amount drawn out.

The accuracy of the scales compares well with the yard scales installed in the railroad yards at the dock, last spring, by Fairbanks, Morse & Co.

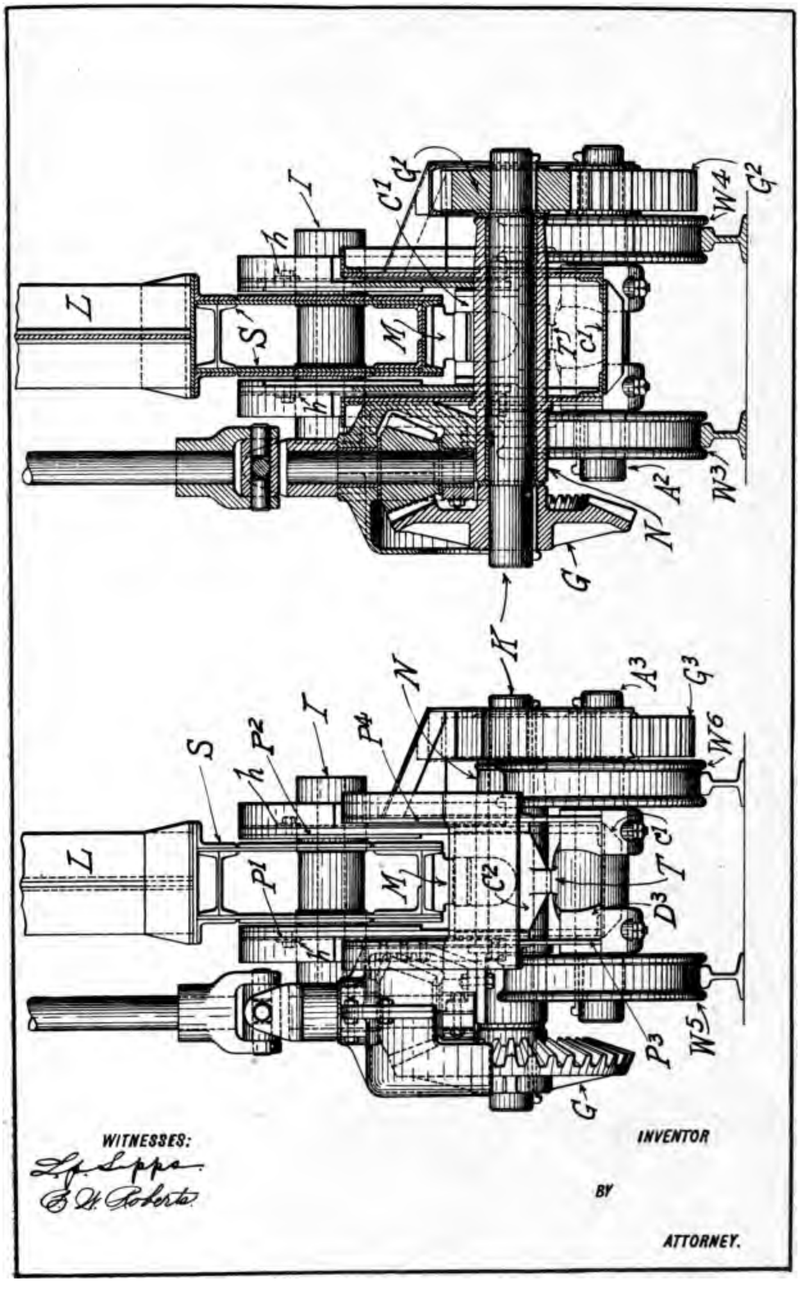
Moving Gear and Apron Hoist.

The heavy truck loads, occasioned by the addition of the 200 ton bin to the new unloaders, gave rise to a special, 6-wheeled and equalizing truck, which was designed and built especially for the new conditions.

The width of the plant over all of tracks, was kept the same as on the lighter machines, which are mounted on four wheel trucks. The six wheel trucks were needed only at the front of the dock, there being no rear cantilever on the plant.

Aside from the new trucks, the moving gear is practically the same as on the older machines, and consists of a 75 H. P. motor, centrally located at the top chord level, driving a line of shafting which connects with a vertical shaft at each leg of the plant, driving four wheels of each truck. (The truck wheels are 24 in. diameter.)

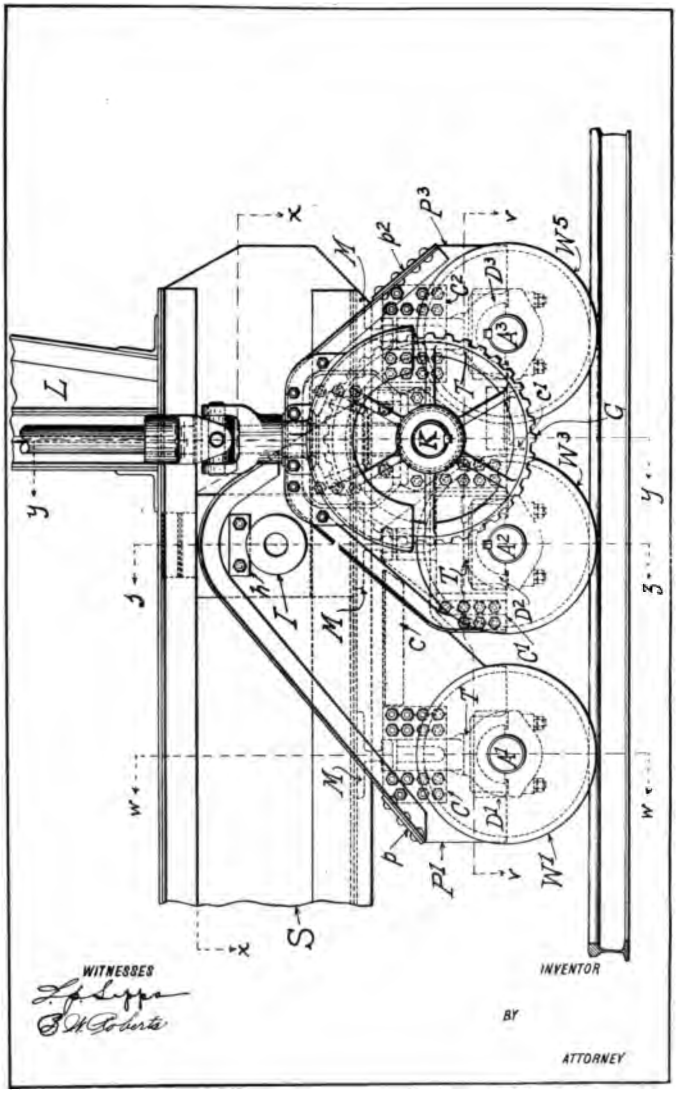
A solenoid brake, on the moving gear shaft automatically locks the moving gear mechanism when the current is turned off.



Elevation end section of trucks

The machinery for raising and lowering the apron is driven by the same motor that drives the moving gear, the two mechanisms being connected or disconnected with the motor by means of a jaw clutch.

Eight parts of 9/16 wire rope are used to hoist the apron, the purchase being 4 to 1. The two hauling parts are wound up



Side view of trucks

on two 18 in. drums on the same shaft, which is connected with the motor by a train of gearing.

A safety brake with a ratchet and pawl arrangement is used to check the motion of the apron in descending, and to hold the load at any point when the power is turned off. In other words, power is ordinarily required to lower the apron, the motor and apron both working against the safety brake.

A foot brake is also provided so that a man can lower the apron without the use of the motor.

VII. OPERATION OF UNLOADING A BOAT.

In taking the ore out of the hatch of a boat, the bucket is first used to dig a trench directly under the hatch opening, the unloader being placed centrally over the hatch.

Working with the bucket in position to enter the hatch, that is with the 14 ft. spread across the boat, the trench is dug to the bottom of the boat, or to a point where the framing in the hold will permit of rotating the bucket. The bucket is then rotated below the deck, widening the trench. Work is continued in this manner until a point is reached where, in addition to the rotation of the bucket, a further reach under the deck can be accomplished by travelling the whole plant. The plant is then moved from its central position a distance equal to half the width of the hatch, thus allowing the bucket to reach 7 ft. under the deck.

With the bucket in this position the hoist ropes touch the hatch-combings.

Before hoisting the bucket out of the hatch, the plant is moved back to its central position, and the bucket rotated back to its original position.

When this type of unloader was first brought out, in 1904, four machines were installed at Conneaut.

The first season, the machines were worked on the day shift only, (working eleven hours out of every twenty-four). There was considerable doubt expressed as to whether the machinery would stand up, under double shift work.

Working single shifts the first season, which was a short one, the four machines unloaded approximately 700,000 tons. For the past three years the machines have worked night and day, during the season of navigation, and have demonstrated their capacity pretty thoroughly.

Exact data for the past three year's work is not available, but 4,500,000 tons is probably not too high an estimate of the ore unloaded during that time.

Six machines of the same type were recently installed at Fairport, and worked double shifts, in 1907, unloading 1,750,000 tons of ore from boats. The four new unloaders on the N. Y. P. & O. dock during the same season unloaded 838,000 tons of ore working double shifts.

The four Hoover-Mason machines on the same dock unloaded 536,000 tons, and the nine old, standard bridges, each handling a 1-ton tub, unloaded 300,000 tons, making a total of 1,674.000 tons, for the season's work at the N. Y. P. & O. dock.

Twenty-five of these unloaders were operated during the season of 1908 at different points along the lakes, representing a capacity of 7,500,000 gross tons for a full season's work.

The four unloaders on the N. Y. P. & O. dock are the only ones that weigh the ore as it is loaded into cars.

Railroad Location
Practice

Railroad Location Practice

By Willard Beahan

Mr. Chairman and Gentlemen:

The subject tonight is not one of the most general interest. You will have to exercise your patience. I shall try to make it as interesting as I can for the engineer in general practice. The topic, the field practice of railroad location, is a limited one, and purposely so, for by the practice I mean, of course not the theory. So that tonight I am not to speak of anything which Mr. Wellington treats of in that great old book of his, which is a library on the subject of railroad train resistance, topography and many other things. I would not, if I could, detract from it, and I do not propose to encroach at all upon the field of that book. When I was a junior, I was taught the little railroad reconnaisance we knew then from the advance sheets of Mr. Wellington's little book, as we called it, the first book. When the present book came out, which I think was in 1886, I got it and I have read it a great deal. Some things in his book have been found to be in error, but it is a wonderful book when you consider it has never been revised in over twenty years.

Tonight I am to talk on the art of location and not the science of it. There is many a young fellow just coming out of college that can do more with the science of railroad location, curve resistance, train resistance and capacity than you or I can. But the purpose of my talk is not in that direction. I am to speak of practice in contradistinction to the theory, and of the *art* rather than of the *science*. My talk, then, will be entirely from the viewpoint of a chief of a locating party.

I assume that the directors of the company know in a general way the kind of railroad the company want. They know what their capital costs, i. e. at what rate of interest they can sell a bond at par. They know, too, the volume of their business and the future expectations. All these things are practically furnished to the chief of the party, by the chief engineer or by some other person in authority.

I am not an old member of this Society—rather one of the new ones, and I feel that before I take up the topic I ought to qualify as a witness, as we say in legal parlance. I began running levels in 1880, in Texas. After serving a good apprenticeship at that, I ran a transit. I took topography for a time and began to revise location under a locating engineer; worked with preliminary parties under Locating Engineer Maj. B. S. Wathen, a man who has done a great deal of work in the southwest, now chief engineer of the Texas and Pacific Railway. He is a man of that school which came into the work at the close of the civil war—of the school to which Davis, of the Northern Pacific; Rogers, of the Chicago, Milwaukee and St. Paul; Washburn, of the Texas and Pacific; Hood, of the Southern Pacific; a little later Frank Davis, of the Canadian Pacific—belong a school of men who have had more practice than any other generation of men ever will have; who were practical men, entirely practical; most of them not educated for engineers at all; some of them were West Pointers. Those were the men who trained me. I learned of Wathen how to make reconnaisance and run lines, and of Washburn how to get on with men. I think I have worked locating parties six winters and four summers. The greatest feat I think was running 900 miles of line with identically the same party. We changed one mule. Whether I did good work or not, there must have been some pretty good management to keep that party together. In the 1,700 miles I used the same Head Chainman for 1,500 miles; the same level rodman for 1,200 miles; the same cook for 1,400 miles. I love railroad location.

I should say that location practice, to take up my topic, as a definition, is finding the right route for a certain railroad and staking out the line there. The shortest distance between two controlling points is a straight line. Distance costs, and if you have no reason for departing from that straight line, there is where you belong. The average chief of party, when he first starts out, a youngster, will follow a creek or wagon road. But it is essential to bear in mind the straight line.

The three great departments of railroad location are reconnaisance, preliminary and location proper. By reconnaisance I mean, as a definition, the examination by the chief of the party of the belt of country for that line. By the belt of country, I mean that comparatively narrow strip within which that line may be located. This belt of country should be thoroughly explored, examined, reconnoitred by the chief of party. The reconnaisance will do away with a great many lines that might suggest themselves to your mind.

By preliminary work I mean the running of trial lines in that belt of country after the reconnaisance is made, with a view to finding out ultimately the best line in that route. This line may be part of one preliminary, part of another. Run all the trial lines necessary in order to develop all the possibilities of that country. The more difficult the country, the more preliminaries you must run.

By the location I mean choosing the best of the preliminaries by careful computation and comparison and then placing the line where it belongs in the route of that preliminary. These are the three great departments.

But there is another restriction; I mean the letter of instructions. It may be a wise letter; it may be an unwise letter, but railroad men are very much like army officers—they have to obey orders. Really, the man who is furnishing the money ought to have something to say. He may say it in a foolish way, but he has the right, and he is generally in the majority. A letter of instructions, then, must be kept in mind. I am going to read to you a letter of instruction which I received and which I thought was very fair. I substitute initials for the names. It is a short letter, and I think about the kind of letter I would write if I was a chief engineer and had plenty of authority:

> "You will proceed to A, and make a reconnaissance for a route from that point to X. We wish to pass through B and C. We are obliged by statute either to pass through D or stay over five miles from D. When you reach the O. & P. Railway you may cross their track at grade, but in any case a connecting track should be provided. When you reach the line of the R. & S. Railroad, you must either go over or under, as we will avoid a grade crossing of that road. The class of the road will be the same as the W. V. R. R., which you located. Consider, therefore, distance to be worth $5.00 per foot. Use no curve sharper than 3° unless unavoidable, and your maximum gadient we desire not to exceed 66 feet to the mile in either direction. Unlike the last line mentioned the preponderance of traffic will be from west to east. Reduction in ruling gradient, or reducing the length of each maximum gradient which is against east bound traffic is most valuable. Communicate with this office, should you find on close reconnaissance that these curvature and grade limitations are not wise. Where you find it best to exceed these maximums of grade or curvature, inform this office."

This letter is an order, as in the regular army. I do think for a young railroad man there is nothing better than to serve for a little while under army engineers. You learn there to obey orders without talking back—one of the essential things in railroading.

The reconnaissance work, of course, comes first. No party is necessary. The equipment required is about as follows: First, a map. In come countries the available maps are not of much consequence; but whatever the country, get a map, the best one you can get, on the largest scale. Today, in this country, we have good coast survey maps, but they do not cover all the territory. However, they are good, and you should have one. Here is an outline of a part of a map (Fig. 6) that we used in Missouri. It illustrates the problem you meet. Get the map that is the best. If you have a mounted map, that is an excellent thing. You cannot very well carry it on your horse, but keep it in camp. Before you start out, get a tracing of the map from the general office. The angle line is drawn through the controlling points, A, B, C, etc. These are points given in the letter of instructions and here connected by a full line. The points A′, A″, etc., are points in the topography which modify the line and are connected by a broken line.

Of course for a reconnaissance you must have some transportation. You cannot very well go on foot, except on a small survey. You must have either a team or a horse for a long reconnaissance. I like best to drive over the entire route with a team and driver, going out and back, and then start on horseback, and you will notice as I go along that I am wedded to a horse for reconnaissance work.

The first important instrument, in my judgment, is a Prismatic Compass. There is nothing peculiar about this compass worth mentioning. It looks exactly like a watch, except that there is a prism at one end. This chain is a piece of Comanche tanned buckskin which was got in Indian Territory. The advantage of this compass over most of them is that the others have a folding sight. The lid or cover makes a sight. This little instrument I used in all the work I ever did. It does excellent work; you can read to a quarter of a degree. I know of nothing better. The great beauty of it is that it is so portable. Don't think you are so excellent in direction that you don't need a compass. How are you going to tell without a needle which way you are going in a fog? If the wind changes, then, where are you?

The next is the aneroid barometer (Fig. 1). Maj. D. W. Washburn gave me this one. I have no doubt that barometer has been used since the civil war. By putting it in this outer case of soft leather I can put it in my saddle bag and it is safe.

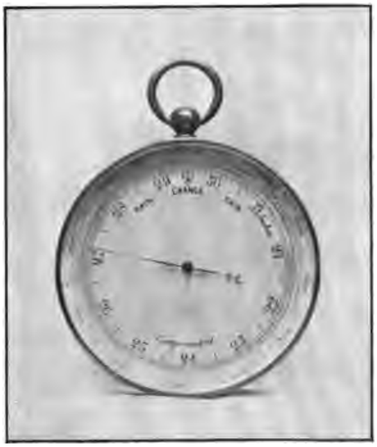


Fig. 1.

Now I have another instrument here that is not so usual (Fig. 2). I think they have been made ten years. It is to get our levels with on long sights, and is called a Binocular Level. The level is in here. It is just like a hand level except the

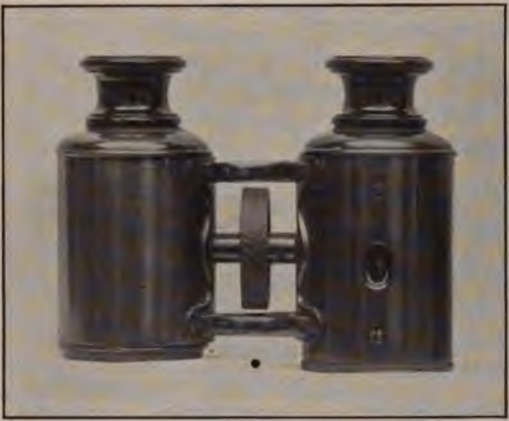


Fig. 2.

longer range, and has a magnifying glass, just like the half of a field glass, so arranged that when you put it up to your eye you will see the object and the cross hair at the same time, and by this magnifying glass you can get a good definition on your object for five mile distances. With an ordinary level you cannot do that. This magnifies something like your field glass. You can take a longer sight, and it is a great improvement over the little Locke level. I don't think it is a very common instrument. I know that not all field parties have it.

Here is our old friend the Locke level (Fig. 3). You have all seen it. When I was a boy I scratched my name on here. I was afraid somebody would get it. This one I let everybody use, and so I had my name on it. I always carry that one in a

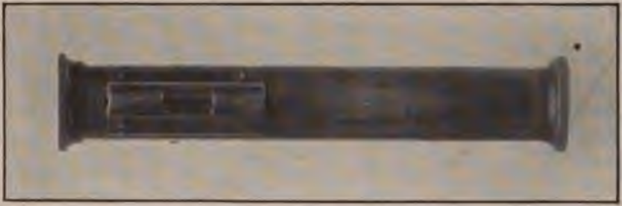


Fig. 3.

pocket slit in the seam of the trousers. That is a very useful little instrument in connection with the aneroid. Mr. Hood told me he could run a line of levels up a five mile hill and get within two-tenths of a foot. The best I could do was to keep within a foot.

Here is a pair of field glasses. They will shut up to accommodate the width between your eyes. Those of you who are familiar with glasses will know that there may be two fields, but if you can close the glass to fit the distance between your eyes, you will see one field. These are English army glasses. This pair of glasses are what we call cool to the eye. A great deal of my work was done in Texas, where the sun was too bright. We have to do everything to save our eyes. The eyes of the locating engineer are very important. His health is important, for if that fails, his eyes get bad, and if his eyes get bad he cannot judge distance. He cannot see. Always try to get glasses that are cool to the eyes.

Then again, as you read Wellington on the subject of railroad location, you will read about that dreadful thing that is called *cul de sac;* that is, you run into a pocket, because there is a break in the hills with another hill behind it. If you have a pair of cool glasses, you will see that in that pocket, probably five miles beyond, there is a deeper color. You will not get caught in that pocket. These glasses are the hardest instrument to carry on horse back; things that flap are very distressing. You cannot get them in the saddle pocket. The only way I could manage them was to buckle my pistol belt around them.

These are all the instruments except a few little things—none of very much consequence. Here is the scale I carried in my pocket; it is marked with the metric, Spanish and English scales. We needed them all in Chili, S. A.; our distances were metric, our areas were Spanish, and our bridges and machinery were in the English system of units. I have some weapons at home—rather grewsome looking things—nothing to do with this particular subject, but quite attractive to younger men of the world. I have here a photograph of my old horse; I think, the greatest horse that ever lived. I may be prejudiced, but I have a right to be. I rode him for ten years, and until he was twenty-two years old, and took care of him till he died. The horse is very important. He saves you and may save your life.

So much for the reconnaissance. You then go to the initial point of your instructions. First you get your elevation. If you start from a point on the railroad, you have that from the office. If you start from a town, you can learn the elevation. A very good way is to take your aneroid and set the sliding circle to read right at the known elevation of the initial point. Make note of this reading on the map. Then range out in front of you in the direction from the first controlling point to the second controlling, as from A toward B″, Fig. 1, beyond a point on a ridge or creek. Note a couple of other points in between as range points. Take the time you start by your watch. You have your saddle horse with whose rate of travel you are acquainted. Now, follow that course to the end of it, or as far as you can see. Note the time; you know the rate that your horse will travel. If you are going in a buggy, have an odometer on the wheel. Get your distance in that way. Read your barometer in the creek bottom. Keep your notes always. You get your elevations by your barometer at the ridges and creek crossings. If you want to check up the barometer in any way, use your Locke level. If you seem to be rising too fast, then test every three or four hundred feet by the hand level and pacing. At the next ridge take a new course, or continue the old one if you possibly can. If necessary, turn an angle with the prismatic compass and range out a new course.

Now, on a reconnaissance you will frequently run into something that ought not to be, but don't deflect for every little obstacle, but take a note, and keep right on. Jump the little ridges, and if the creek crossing is not quite right, so long as you are not running lengthwise of the creek, keep going. Stick to your reconnaissance directions between the controlling points given in the letter of instructions. Continue that way to the end of the line, noting what you see. I am not in favor of going off that straight line in the first time over the route. Of course, if you are traveling with a team, you cannot follow, but you can follow on horseback. Keep full notes. It is a survey. You are measuring with your horse; you are doing instrumental work as you go along. It is entirely up to you. It is not close, but it is close within certain limitations; a great deal better than guessing; far better than sitting in an office and looking at a map.

In reconnaissance there is one thing to bear in mind. Get the streams from the map as you see it. There is no such thing as reconnaissance without paying attention to the drainage. You must know which way these streams are running. When Mr. Washburn started me out under himself on a preliminary, after I had been to school, as a subordinate on parties, he said: "My boy, you will never succeed as a locating engineer without you get this idea of drainage in your head," and holding up his fingers like this, he said: "The drainage of the country is the framework on which you must hang your located line." Now, of course, if the drainage is running with you, it is comparatively easy; but in the general case it doesn't run with you. If it runs squarely across your direction, you are in trouble all the way. Generally it will run diagonally. But the drainage is the frame work on which you *must* hang you line.

As to the preliminary line. After you have a reconnaissance of the line, or fifty miles of it, at least, then look over the country carefully for the first ten miles. When you have done all this you are ready to organize your party and start to work. I do not propose to go into the details of the organization of the party. Most of you know what it is. Chief of party, an assistant, transitman, levelmen, rodmen, etc., thirteen men in the party, if we lived in the hotels, or what we called a quartered party. If the party was a camping party, we had sixteen men. The camp equipment, of course, is tents enough—we had four; teams enough —we had three, sometimes five. I might say here that I believe we do not use camping outfits enough. I think it more expensive to get along, even in this country, with a quartered party. You cannot do so much work. I am not at all in favor of living in hotels. I believe in camping. You have got your men together and can keep better discipline. I thoroughly believe in camp work. Mr. Washburn said he had difficulty when he brought a chief of locating party from the east and put him at work in Texas, because he was not familiar with camping out. He said it was one thing to be a good locating engineer, and another thing to be a good chief of party. I will just show you what I mean by camping out. Here is a camp lay out (Fig. 4). The fronts of these tents are straight on a line. Three are 14 x 16, and one is 16 x 24. About 100 by 200 ft. is the ground space you need. The tents faced south in the winter time, for the winds come down from the north or northwest, and in the winter time we put the backs of our tent into the wind. But in the summer time we faced them east so that the heat and sun would be on the rear of the tent, and cool in front. Everything there was arranged in a certain order. When we had a storm at night, or the Indians came in on us, we didn't even light our lights, since

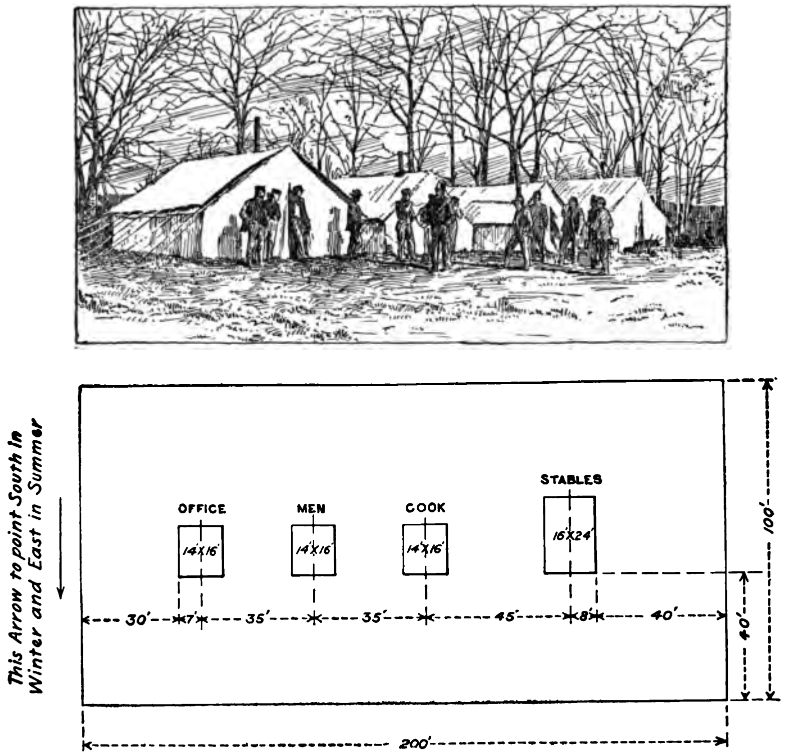


Fig. 4.

we could put our hands on everything. So much for the preliminary layout. Now, you start your line, of course from the same initial point as that from which reconnaissance started. As you make your reconnaissance for this day's survey, you take a note-book and sketch for the use of the assistant notes to guide the party, the assistant never having seen the country. This is not at all a difficult thing to do. Here is an outline sketch showing horizons (Fig. 5). This sketch must show the drainage in general and very correctly along the line, so that the assistant can see that he is on the ground chosen. Trees, bushes, rocks and elbows of streams are best to show this. If it be a prairie country a "horizon" can well be used to show where the line crosses a ridge. By a horizon is meant a profile of the outline of the next divide as it appears against the sky. Its object is to show the assistant where the angle he is turning, as at Q, Fig. 5, should cause the transit line to cross the next divide, as at R. Where timber or brush interferes with seeing the horizon or other distant objects, the courses to be run must be *flagged* out. By this is meant tying a strip of cloth to a bush or limb of a tree. Strips of white cloth one inch wide and one foot long are used in summer, and red and white in snow. Where many flags are

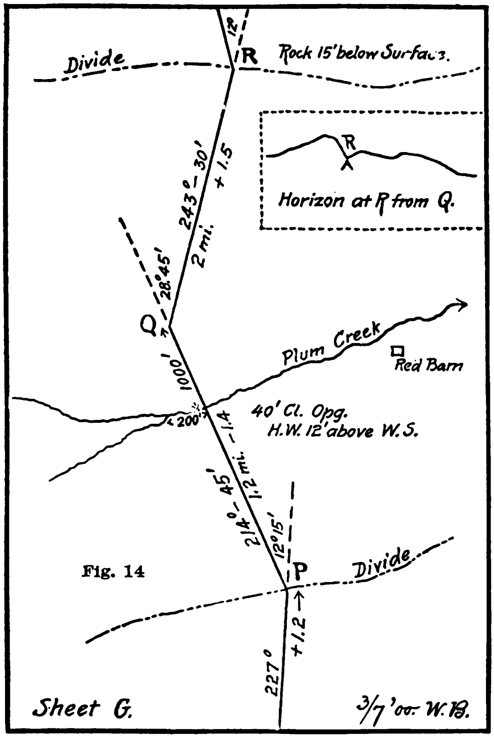


Fig. 5.

used in thick timber, it is useful to mark the letter on a flag in pencil whenever that flag marks on the ground a point shown on the sketch by the same letter. The color of the flag must be in contrast to the background on which one is to see it.

The preliminary line is to develop the country within a certain narrow limit. I think that in prairie country you ought to run but one preliminary. You ought to be able to get a line with one preliminary; by that I mean you ought to get within 200 feet of the located line. In Kansas, Nebraska and Missouri we used to put our camp five or six miles ahead of the initial point and run the line as much farther beyond the camp. Then locate from that preliminary camp. It needs much reconnaissance to do this safely. I rode thirty-five miles a day on horseback. I believe in this thorough reconnaissance by yourself, and having the party run the line as you find it.

There are two ways of locating a line—office method and field method. The office method has been advocated a good deal by the late Dean Johnson, in his books, and it is the way they do in the old country. Take any map, or a map of your line, and make the calculations in the office, and it is a very expensive way of locating a line—a very dangerous way. The trouble is in putting a man doing work to a very small scale. I do not care how big the map is drawn, it is much smaller than nature. It is a great deal easier to see how the line is, spread out, with the sun shining on it, than it is sitting in the office. The dangerous thing is not that you will pick out the wrong preliminary of several surveys, but that you will never see the right preliminary at all—never run a line in it. When you have spent a good deal of time finding a line, and you have it located and built, some man comes along and finds a line that is better. There are mountain passes that have been found and named after men who found them and located the lines in them which blight the memory of those men. My idea is that the only way to be safe is to take a good scale map, mark the route, and ride forward and back on that route, observing and noting.

To ride on a reconnaissance for a preliminary, assume that you are camped on the line and the party running line that day back of camp. Suppose this day, for simplicity, is the first day you have reconnoitered beyond that camp for a preliminary. Note your barometer reading, the time of day, the course by the prismatic for the line from camp to the next controlling point—mount your horse and start. Ride him on that course. Read the barometer at the next creek for elevation; note the time and record the distance found by the pace your horse goes and the time elapsed. Look up what you need to know about bridging that creek. Continue on to the ridge where you again note distance and elevation. Try your prismatic compass to show the same course beyond. Suppose it would land your line lengthwise of a creek elbow. Then turn an angle to avoid it. Note the angle, get range points on the new course, and ride on. If by noon you are fifteen miles from camp and the ground has been favorable, generally, then ride to right or left four or five miles at right angles, picking out the side of the examined line which seems the best ground. When you have gone wide enough, give your trained horse his head and let him go straight to camp. Keep notes. Next morning go out on the other side of the line explored the previous morning. It is really a great responsibility for a young man. There is plenty of locating done, that does not deserve that name at all. There is not enough work put on it. There is not enough hard, conscientious study, and if you do not see the country, you cannot possibly expect to find a line in it. The only way to see it is to travel over it with every help you can get. The danger, as I say, is the line you never see.

The field method of location from the preliminary is the surveyors method. Seeing where the map or the profile needs improvement, the chief of party modifies his previous line on the ground, to better that line. He "backs up" on his deflected curve or he "goes ahead" on it. He tries to fit the line to the ground by trial in the field. It is uncertain work and expensive. It was the old way. But this purely field method of railroad location is now little used.

So much for office and for field location. I think the best method is what some call a combination method. Plat all of the preliminary lines on the same sheet. Run your preliminaries between the two controlling points for that place. Mark the stakes and plats, blue for your first, black for the second—each line with its color. I usually marked our profiles and the map the same color. We will assume that you make your calculations and work out an estimate for each preliminary line. You decide that one of these lines is the right line, and plat it on that map. You then want to locate that line in the field. If you travel over that country in the way that I have indicated, and run three or four preliminaries, there is not much chance that the right line has been missed. Plat the best line on map and profile. Then you go out yourself and walk over that line, with a hand level and the map and the profile. Find where that located line, projected on paper, is wrong, and where it is right. Always when you get back at night, shift that located line if it is wrong. Next day your assistant, after working over it in the office, runs it in. After he has done so, you go back over it again and check all the points carefully on foot. I think when you have located a line that way, you have located it the best way. I know it is rather hard work, still in the end it seems to me the best way. I call that location in the field.

The scale of a map depends on the use to which you wish to put that map. We used two thousand feet to the inch. A thousand feet to the inch is none too large a scale. When you have figured out a preliminary and located it on paper, you need a scale of about 400 feet to the inch. If you use 400 feet to the inch, and use the usual scale for the profile paper, then your map and your profile are the same scale, which is some advantage. We used the small scale profile in the old days; the Plate A scale is better—15 ft. to the inch, vertical, but it is not so convenient for the preliminary in field work. On the Missouri Pacific we copied the note book, traced the map and copied the profile and sent in this for each ten miles of located line. On that map and profile and note book we were supposed to put, and had to put, all of the information which the chief engineer would need in order to take action to condemn the right of way, buy material and let the contracts to build the line. Now, I consider when the locating party has done that, it has done all that is necessary. This note book cannot be made intelligible to everybody, but is clear to the chief engineer. We didn't make a map that was wanted for final record, but the facts were all there, and a final map was made from the notes we sent in. The information was all there, and was correct. This is a working map (Fig. 6). This is the air line drawn on the map according to instructions. I was told to run from Council Bluffs to Osage City. The grading averaged some 24,000 cubic yards to the mile. There were 30 degrees of curvature per mile. That is not a very straight line. Now, this located line was 5 1-3% longer than the air line. You see you can vary quite a little and not lose so very much distance. That is a good, fair average. I think if you lose 8% you are doing very well; if you get down to 3% you are going remarkably well. It should be a pretty bad country when you need to lose more than 12%.

Here is an instance of a supported line (Fig. 7). This is the south end of the Peoria line of the Chicago and Northwestern, which I located some years ago, but did not construct. This is going down from a high tableland to the Illinois River, at Peoria. Here we go into a canon, 1% grade. This is called a supported line—that is to say, we put this line on the side of that canon so that the cuts made the fill all the way down. We put it as closely as we could, and in the construction the engineer told me that he had to borrow practically 1200 cubic yards. In a difficult country, if you support your line and do not exceed the maximum grade, that is all you can do. When it gets so difficult that you cannot support it, you have to do what is done here.

Fig. 8. Tehachapi Loop.
Fig. 9. Georgetown Loop.
Fig. 10. Cascade Switchback.

Such is the practice. The theory I have not touched upon. I fear that what I have said has too much ego in it—too much of my work and not much of the other fellow's work. But I have spoken only of work I have done. I did want to put this work before you, show you these instruments and show you what has been done with them. It is the most fascinating branch of the engineer service in my experience. Nature is never monotonous. If she were monotonous and made one piece of country just like another piece of country, I am sure that no two railroad companies would wish to go through that country in the same way. I hope that this will aid you to an appreciation of the work that some of us have tried to do in our lives, and will help you to understand a little bit of the difficulties and problems we have had to deal with.

Mr. Hoffman:

The paper this evening has been rather interesting to me, among others, for the reason that it describes a field of engineering that invariably appeals to a young man before he ever starts in to study engineering. I feel that many a young man has an idea that he would like to take up engineering work because he has in his mind's eye the kind of work that Mr. Beahan has described, and yet how few of us, after our work in school, ever get an opportunity to go into this class of work. Personally it seems to me I know very few locating engineers, and it is very seldom that I have been able to hear a paper along the line that Mr. Beahan has presented this evening. There are a number of men here who, I think, would be very glad to talk on the subject.

MR. SEARLES.

I have listened with great interest to this narration of one engineer's experience. It is permitted to few men to narrate their own experience rather than that of another. If, for instance, a surgeon had performed a masterpiece of work in his line, and afterwards described to his brother surgeons what he had done and how, and the result, they would appreciate his effort because it grew out of his own experience; what some other fellow had done they could read for themselves. So we are glad to have these details brought before us by a man who evidently knows what he is talking about.

The ideas he has expressed agree with my own, but I expected some reference to be made to the contours of the surface as a guide to the solution of the location. I have found that, in addition to what has been described in the way of reconnaissance and preliminary survey and several preliminary surveys in the same region, it is a great advantage to have full notes of the cross profiles at right angles to the line as observed at each station. For this purpose I have used a hand level with a graduated arc, in the hands of the chief of party or some one near him. The ordinary transit pole is sent off 100 feet or 200 feet at right angles to the line, the man holding his fingers on the pole at the same height above the ground as the eye of the observer who stands at the station while taking a sight at the fingers. The line of sight is thus made parallel to the slope of the ground. The reading is noted and also the distance to which that particular slope extends. The slope beyond the first, and its extent, may be noted also. It requires but little time to take these notes, but they save a great deal of time later on. If the center line as run does not properly support the given grade, a glance at these notes or the contour map made from them will decide how far the line should be thrown to the right or left to correct the difficulty. The proposed location is expected to be somewhere within reach of the preliminary line, but this method of slope taking defines a much wider belt of country than the method of taking individual contours, and requires much less time on the survey, and less men in the party.

I had occasion recently to make some preliminary surveys for a road 120 miles long. A reconnaissance which had been made previous to my coming, had been made, not on horseback, nor in wagon, but from an automobile, and was of little value beyond indicating the intention of the company as to general route. Three parties were put in the field under chiefs, who were young and rather inexperienced men, though in the matter of obeying orders they proved to be very good men. Consequently I had to assume the responsibility of selecting the line for all three parties, and this without having time to go over all the ground myself. Fortunately we had government contour maps of that district, though on a rather small scale. I simply took these maps and after a careful study of them under a reading glass, traced upon them what appeared to be the best location according to the contours, and made from them a profile of the same. Where necessary the line on the map was changed to improve the profile, and when both were made satisfactory, copies of them with explanatory notes were forwarded to the chief of party for his guidance. It was remarkable to note how very closely the profile of his survey agreed with the profile projected from the government map.

In one instance, however, the result was very disappointing. The contours at this place, which was the lowest point of a divide, were one hundred feet too low as printed, and the consequence was that instead of an open cut as expected, a long tunnel was indicated. It became necessary to abandon that locality altogether in favor of another which required no tunnel. Eventually, as the work proceeded I became familiar with the natural features of the whole route, but in general the method above described was justified by the result.

On the profile of the survey and to the same scales were platted at each station the transverse profiles, thus showing at a glance, not only where the centre line intersected a contour, but also the distance right or left from any station to any contour. This made the platting of a contour map easy work. As it was not desirable to make the final field location in advance of the required report and estimate, the same method was pursued of making a paper location, but this time upon the new map which was drawn on a large scale with all details. On this a complete line with curves was projected, its profile taken off from the contours, the minor details being supplied from the preliminary profiles as necessary. In tracing the map all preliminary lines were omitted, and so the tracing and profile became the basis of an elaborate report and estimates. Our knowledge of the ground by this time was so thorough that it would not be difficult to realize on the ground the location of the line indicated on the map. The combination of field and office work gave us several short cuts to the result desired.

I do not believe in office work independent of the field work, and before this final location which I was describing was platted on paper, I went over all that line on foot with the maps and profiles in hand, as they had been made by the party, so that I became familiar with the ground itself, and jotted on these maps such notes as were necessary for further guidance, and then I felt that when I made the paper location I was simply doing on a small scale what I was prepared to do on a large scale when opportunity should offer.

I have generally felt that the locating of individual contours was too expensive because it took too much time; so I prefer taking the transverse slope, right and left. The only measurement required is from the stake to the point where the slope changes, and if we wish to extend our information, then from that point to another point in the same direction where the slope changes again, and so on. There may be many or few contours between the stake and the last point, and it does not matter. But to locate them definitely requires a reference to a bench, the use of a level, a rod and a tape, and the time of three men, and a lot of figuring. The points are obtained with unnecessary precision, considering the scale of the map to be made from the notes. Should the test levels show the bench to have a wrong elevation all the contour work done from it is vitiated.

When the slope method is used and the slopes are platted on the profile, as already explained, the distances to the contours may be scaled off at once and transferred to the map. Moreover we may use any vertical intervals we please, as 5, 10, 20 or 25 feet, and take off the distances with equal readiness.

HOSEA PAUL.

It is our good fortune tonight to have the interesting subject of railroad location discussed by a man whose experience has not been desultory or occasional, but shows a record of continuous service in real railroad building not often met with. For while some of us have also located a considerable mileage in the aggregate, it has been an unusual privilege to follow the work year in and year out systematically and thoroughly, until a total of twelve hundred or fifteen hundred miles, if not more than this has been reached, and it constitutes I say, a rare and unusual experience. I am glad, too, that Mr. Beahan gives us so many practical details. Some of them indeed bring back memories of the old entrancing life in the open, of the beauty of field and plain. I was impressed first of all by the thorough system of reconnaissance. I think every locating engineer will appreciate this, especially when he recalls instances where circumstances did not seem to permit him to make this preliminary examination, where not infrequently his employers expected him to organize a party and begin driving stakes possibly without enough personal knowledge of the country to serve the first day's run, and which lead he could only gradually increase as the work progressed.

Nowadays we have a great advantage in those localities mapped by the U. S. Geological survey, but I agree with Mr. Beahan that the locater must use his eyes, must see the ground, and that no map, however detailed and elaborate, can enable him to wholly delegate the work. This indeed brings us to the much mooted question of field versus office location. I believe a good deal depends on where the office is. If it is carried right along with the work under the direction of the locating engineer, it is a different matter than if the notes are sent on to a point perhaps five or six hundred miles away. An early experience of mine was on the extension of the Michigan Central to Mackinac. The chief of party was Mr. E. H. Phelps and the transitman was Mr. Augustus Torrey, both of whom afterwards served as chief engineer of the whole road. They were both untiring, conscientious and thorough to a degree rarely met with. I was topographer and the best training I ever had was here. Our custom was to plat up the day's run every night and when this was done by the leveler and transitman I put on the contours and other details and helped the engineer project a revision of the line, if such was necessary, as it usually was, to be run in the next day. This constant revision of the line was especially necessary because so much of the course was through thickets and tangles of cedar swamps, which you could hardly penetrate, and where the view was so much restricted that the facts obtained by the topographer were the main reliance for anything more than fifty feet away from the narrow vista cut out by the axmen. I do not, however, approve of so much night work, even if some of it is occasionally necessary and unavoidable. There should be a good draftsman with every field party in camp, if the party camps out, and otherwise as near to it as possible. If you depend on night work on the part of the field men for this, it is a mistake, as well as an imposition and either the work or the men will suffer.

As to camping out, I realize the many advantages over hunting up quarters at farm houses or hotels. My last experience was in running a line across the state of Indiana, and I was much pleased with the success of it, but I will call attention to the difficulty in getting camping sites in a settled country. I hardly know what we would have been able to do in some instance if it had not been that it was at a time when the country schools were closed during vacation and we could camp on their grounds. We certainly would have had to spend more time in the selection of sites if we could not have obtained them. When I set out on this Indiana survey I found an equipment already purchased, which included a cook tent and a big one, some 16 x 28 ft., with end guy ropes, extending some forty-five feet. It was a good deal like setting up a circus tent, as we had to measure off the place to set the pegs. To raise it properly took seven men. When the ridge pole came, it was tied on the outside of the car, and as it was too long for the wagon, I had it cut and a sort of a fish plate joint fixed up, and one man was assigned the responsible task of bolting up and separating it. As quickly as possible I secured tents of the size I had used in the west.

Another thing worth mentioning is the frequent waste of time and effort in running preliminary lines without making sufficient record. One of the easiest and best ways to do this is to draw the line across the face of an ordinary country map. These are usually two inches to the mile and if the houses are located it is surprising what a good idea of a line run can be had by making use of them in the way indicated. While this does not take the place of more elaborate maps, they supplement, add to and make more available the best of them.

MR. HOWARD.

I thought of making a few remarks on some of our work in the Allegheny Mountains, a different class of work than that spoken of by Mr. Beahan in a good many respects. I will only detain you a few minutes. We find that a good many different problems confront us as we go along that are not strictly engineering. But the engineer has to contend with them.

A few years ago I had charge of some surveys for the Deepwater and Tidewater Railways, now the Virginian Railway. These surveys extended from Kanawha River to the Chesapeake Bay. We had to cross a good many different mountains and rivers, and had to decide on various different gradients, but one of the most difficult things was the opposition of other railroads.

The Virginian Railway commences at Deepwater, a small village on the Kanawha River about forty miles above Charleston, W. Va., extends up the Valley of Loop Creek to its headwaters, crosses the intervening mountain range through a low gap to the waters of Paint Creek; thence up the valley of Paint Creek and through another gap into the headwaters of Coal River; thence by a tunnel through Jenney's Gap into Slab Fork of Guyandotte River; thence down Slab Fork, crossing the river up Barker's Creek; thence by a tunnel through the Flat Top Mountain Range at Clark's Gap and down another valley; thence across the Princeton Mountain summit; thence down into the Valley of New River; thence crossing New River and along the east side of the gorge; thence by a tunnel through the Allegheny Mountains near Christiansburg, Va., to the waters of Roanoke River. It follows Roanoke River to a point west of Chase City, Va., where the Roanoke River turns southward towards North Carolina; and thence cuts across the country to Norfolk, Va., and Sewall's Point on the south side of Hampton Roads, opposite Old Point Comfort.

Any one sufficiently interested can trace out the route on the state maps. On the first 85 miles of the line, we had a good deal of opposition from other railroad companies running rival surveys, and each one trying to get their line located first. The question became how to get the best gaps and best line down the gorges first. We had to divide our different parties, run this summit, down this hill, and down here, and had big lawsuits over the gaps with the other roads. We started at the gaps; assumed the length of the tunnel, and tried to get the location in quickly. The laws all over the country now are pretty much the same in one respect—the man that gets his location in first gets the prior right, and if it is a narrow gorge, as far as a particular side of the gorge is concerned, the man that gets his line there is elected, and the other man is cut out. There were one or two pretty big lawsuits about these gaps. The most famous one was at Jenney's gap. That suit went to the Supreme Court of the state. Another one was Clark's gap, and was compromised by arranging so that each railroad company could get a tunnel through the gap without interference with the other. The engineers of one opposing railroad made use of the method that Mr. Searles has spoken of. They took the government sheet with small 100 ft. contours, enlarged it and filed it at the state and county courthouses as their adopted location. We put an engineering party on and ran over every line they had surveyed. We took the same government sheet, platted, and enlarged it, almost exactly like the one they had, but the point that gave their case away was that there was a big loop in the creek that had not been shown on the government sheet, and in addition to that in respect to grades and elevations, it was entirely different from the lines they had run on the ground.

When it came to the question of going east from the Guyandotte River towards Norfolk, we anticipated that just as soon as we started, we were going to have all kinds of opposition. We had three men on horseback secretly scouring the country for about four or five months, and had all the government maps we could get. They made very careful reconnaissance, but the main thing was to make the profiles. We made an approximate profile showing the grades of the whole line from one end to the other. From New River to Norfolk we got very light grades. From the river to the Allegheny Summit was a 6-10 compensated grade, and from there to Norfolk no grade against traffic exceeded 0.2% compensated. We made that profile from reconnaissance, showing grades exactly. The same grades almost identically were obtained on location.

We quietly set to work, having this reconnaissance; organized ten parties; put them in the field, distributed along the most difficult mountain gorges where we would expect the most opposition. We made out orders for each one of these parties in advance, type-written, everything filled in except the name of the chief of party, the point he was to start from, the point he was to go to, with complete directions, everything, in fact, except these few blanks to fill in. We organized seven of these parties in New York City, and three of them in West Virginia. They got there almost simultaneously; possibly two or three arrived the day following, and the next morning "our friends, the enemy," found the country alive with engineers. On this part here we didn't have any trouble with lawsuits. It went off just like clock work. Some of that work wasn't very good, but it had the result of covering the ground so that no other railroad could run a line on the same side of the river or gorge and shut us out.

In mountain work I believe it is essential to make trial reconnaissances in every possible way, and along every possible route. In addition to that it is necessary to "fill the wods full of stakes." It is hard work to get information. You have to run every possible line in order to get the right one. We had a good deal of experience with the U. S. topography sheets, which were a great help, but in one case we found that the government map was about 100 or 150 ft. too high. But in regard to topography, I think in mountain work it is best, whenever you run a preliminary line, to run it carefully, and take the contours on it. We used to take 5 ft. contours on every line we ran and it didn't delay the parties at all, because you would run a transit line and level anyhow, and the topography parties could keep up with the others. That is the wisest thing to do in the mountains. We had our parties arranged rather larger than Mr. Beahan spoke of. We had one topographer, two rodmen and two Locke levelmen to a party. That would mean five men including the topographer. Just as soon as we got through one of these surveys here, we made a location. Some of this work we did so rapidly was run correctly, but some of the contour work was so incorrectly done that the work of two or three parties for two or three months had to be thrown away. We had to do it over again.

Now, in regard to what Mr. Beahan says about the work in the field. I think that is all right under certain conditions. When you have the best locating engineer you can find, and he has time to do it all himself, it is all right for him to project his line, but as I say here, we had about ten different parties at one time, and probably two or three of the chiefs of parties could project a line as well as anybody else could. But every one of them would project differently. We found that the best thing to do was to have each chief of party project his line as well as he could in the time allowed him, and send the sheets in, and then we had our experts in the office, the best we could get, go over these sheets and contours and revise their projections, and I think we would always save a good deal in that way—probably about 30% in cost and get equally as good a line, and perhaps less curvature.

But I think it is by all means best to have the chief of party project his line in the field so he will know what he is doing. But you cannot trust to them entirely because no two will project alike. By all means it is wise to have the work checked over in the office. We had a locating engineer in charge of all these parties—in charge of the whole operations, and we had three

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division engineers—each one had charge of about three parties, each party being composed of about sixteen men.

As to scale, I think on mountain work you should use a scale of 100 ft. to the inch and have it platted on the sheets, so that you can make a projected profile exactly the same as the location. Our actual profiles in general were almost exact duplicates of the projections. You could not detect any difference of any consequence in the profile. The projections were substantially correct, and we would run in the location on the ground from our notes (referring to the preliminary as a base line) without ever stopping to compare profiles, feeling confident that the actual location profile would be practically a reproduction of the projection.

MR. TINKER.

It has been remarked that methods differ with the country. I think that is true. Take one small detail. Mr. Beahan showed an arrangement of camps which is very nice where it can be obtained. My experience has been in mountain country, and the question there was not of locating the tents in a straight line, but of finding a level place to set a tent upon. Following out the same idea, there is the question of scale of maps; what is best in one country is not in another. I think a scale of 400 ft. to the inch, for what might be called ordinary country, is all right. For mountain work there will be short stretches where 200 ft. to the inch is better. I never happened to get into country where I thought it was necessary to have a larger scale than 200 ft. to the inch. For a flat, level, prairie country, where it may be two or three thousand feet to five feet rise, a scale of one thousand feet to the inch is large enough. The question of the scale of a map depends upon the contour interval. The scale should be large enough to show the different contours with clearness; if you have a difficult problem, you may want 3 ft. contours, and if you decrease the contour interval, you must increase the scale of the map.

The companies for which I have worked have been organized a little differently from what Mr. Beahan has described. The general reconnaissance was done by one man and the preliminary locations were run by different parties. The chief of each party made his detail reconnaissance from day to day, as described by Mr. Beahan, but the general reconnaissance was made, and the general route of the line determined by one man who was not chief of the party but was called reconnaissance man, and all the locating parties were under his direction, somewhat as described by Mr. Howard, where one man had ten parties under his charge. We would run our preliminaries with the party generally in charge of a transitman. He ran them as directed by the chief of party from day to day, and the location was projected by the chief of party afterwards, run out in the field by the transitman, and then the chief took his maps and profiles and went over the located line on foot, looking it over carefully in detail, and if he saw where any improvements could be made, that part of the line was relocated.

I believe in taking a large amount of topography. By the use of the Locke level or the Abney level with the arc, it is very quickly done. Under our organization the topography party consisted of three men, using tape and hand level. They were able to keep up with the transit party, where we were running from five to eight or ten miles a day. If the country is so open that a party can run more miles than that, the work of the topography party is less, so that they can keep up just the same; but if the country is much broken, then the topography party would have difficulty. These topography notes were platted by the draftsman, and the maps were always one day behind. The notes were always figured up at night, transit line computed, profile platted; the next day the draftsman put the line on the map and platted the contours.

I do not think it is a good plan generally to move camp as often as once a week; too much time is spent moving camp; the bulk of the time is occupied in taking tents down and setting up again. You can just as well move fifteen or twenty miles, as ten miles each way from camp is not too great for the longest ride morning and night.

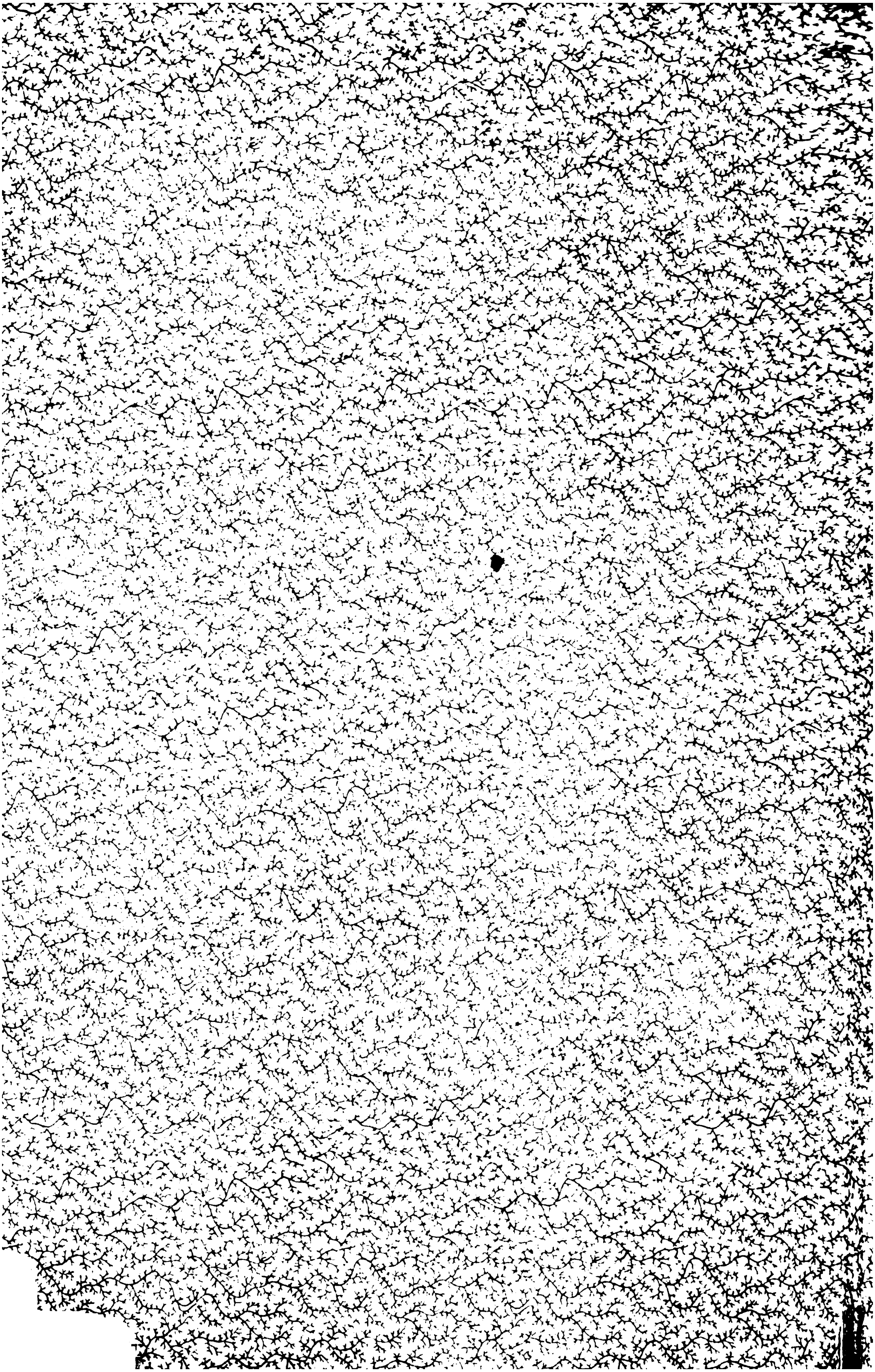
As to the question of platting the line on small sheets and taking the sheets out into the field. I have seen that tried; have also seen tried the scheme of platting the line on a long map and taking that into the field and platting contours on it. I think that is a waste of time. The small sheets are not of a great deal of value. If the topography is carefully taken, the notes carefully recorded, the figures are just as good as a plat, so far as a study of a small portion of the line is concerned. I have known a number of men who would throw the maps aside and study the line from the notes; notes give the distance for a rise of five feet, and that is what they want to know. Of course, the picture is useful, but the platting of this on a small sheet and afterwards transferring it to a large map is largely a waste of time; the notes should be carefully recorded in a book and platted on the large map; the labor of doing that work in the field should be saved.

Mr. Howard: Referring to the method of sheets as explained; I have done that a great deal. We also took notes in a book. The man that used the hand level took down his notes in his book. It is easier to draw your contours on the sheets than it is to draw them in a book. If you want to transfer contours to a big map, it is also easier to transfer from sheets than from the book.

Mr. Tinker: Some men prefer one method, and some the other. It is not necessary to plat contours in the book. If anything more than the figures is needed, a sketch is sufficient. Platting should be done in the office where accurate work is more readily done. Transferring lines from one map to another is not an accurate method of doing work. The map should be platted from the original notes.

Mr. Beahan, in conclusion: I want to thank you for the very sympathetic and very kindly discussion. I don't know how it is with you, but I have changed my mind on one old belief of mine. I used to think that locating engineers were tongue-tied, but I see we are not.

Mr A



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